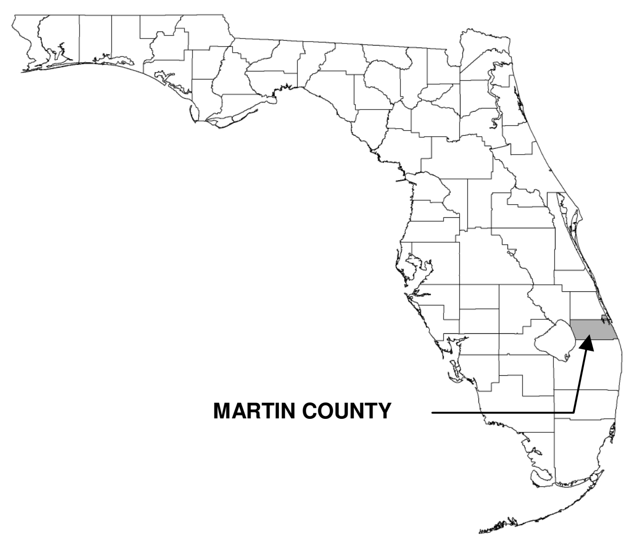
FLOOD INSURANCE STUDY

MARTIN COUNTY, FLORIDA

AND INCORPORATED AREAS



Community Name	Community Number
JUPITER ISLAND, TOWN OF	120162
MARTIN COUNTY (UNINCORPORATED AREAS)	120161
OCEAN BREEZE PARK, TOWN OF	120163
SEWALL'S POINT, TOWN OF	120164
STUART, CITY OF	120165

REVISED – Month, Day, Year

Federal Emergency Management Agency

FLOOD INSURANCE STUDY NUMBER
12085CV000B

NOTICE TO
FLOOD INSURANCE STUDY USERS

Communities participating in the National Flood Insurance Program have established repositories of flood hazard data for floodplain management and flood insurance purposes. This Flood Insurance Study (FIS) may not contain all data available within the repository. It is advisable to contact the community repository for any additional data.

The Federal Emergency Management Agency (FEMA) may revise and republish part or all of this FIS report at any time. In addition, part of this FIS may be revised by the Letter of Map Revision process, which does not involve republication or redistribution of the FIS. It is, therefore, the responsibility of the user to consult with community officials and to check the Community Map Repository to obtain the most current FIS components.

This preliminary revised Flood Insurance Study contains profiles presented at a reduced scale to minimize reproduction costs. All profiles will be included and printed at full scale in the final published report.

Initial Countywide FIS Effective Date: October 4, 2002

First Revised Countywide FIS Revision Date: Preliminary

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FLOOD INSURANCE STUDY
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1.0 INTRODUCTION

1.1 Purpose of Study

This Flood Insurance Study (FIS) investigates the existence and severity of flood hazards in, or revises previous FISs/Flood Insurance Rate Maps (FIRMS) for, the geographic area of Martin County, Florida, including: the City of Stuart, the Towns of Jupiter Island, Ocean Breeze Park, and Sewall's Point; and the unincorporated areas of Martin County (hereinafter referred to collectively as Martin County). This FIS aids in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. This study has developed flood risk data for various areas of the county that will be used to establish actuarial flood insurance rates. This information will also be used by Martin County to update existing floodplain regulations as part of the regular Phase of the National Flood Insurance Program (NFIP), and by local and regional planners to further promote sound land use and floodplain development. Minimum floodplain management requirements for participation in the NFIP are set forth in the Code of Federal Regulations at 44 CFR, 60.3.

In some states or communities, floodplain management criteria or regulations may exist that are more restrictive or comprehensive than the minimum Federal requirements. In such cases, the more restrictive criteria take precedence and the State (or other jurisdictional agency) will be able to explain them.

The Digital Flood Insurance Rate Map (DFIRM) and FIS Report for this countywide study have been produced in digital format. Flood hazard information was converted to meet the Federal Emergency Management Agency (FEMA) DFIRM database specifications and geographic information standards. This information is provided in a digital format so that it can be incorporated into a local Geographic Information System (GIS) and be accessed more easily by the community.

1.2 Authority and Acknowledgments

The sources of authority for this FIS are the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.

This FIS was prepared to update the October 4 2002 initial countywide FIS. Information on the authority and acknowledgments for each jurisdiction included in this countywide FIS, as compiled from their previously printed FIS reports, is shown below.

Jupiter Island, Town of:	the analyses for the FIS Supplement – Wave Height Analyses dated July 5, 1983, were prepared by Tetra Tech, Inc., for the Federal Emergency Management Agency (FEMA), under Contract No. H-4510. Dames and Moore subsequently mapped the wave crest information for FEMA under Contract No. C-0542.
Martin County (Unincorporated Areas):	the hydrologic and hydraulic analyses for the FIS report dated December 15, 1980, were prepared by Tetra Tech, Inc., for the

Federal Insurance Administration (FIA) under Contract No. H-4510. That work was completed in June 1979. The analyses for the Supplement - Wave Height Analyses dated July 5, 1983, were prepared by Tetra Tech, Inc., for FEMA.

Ocean Breeze Park, Town of:	the analyses for the Supplement – Wave Height Analyses dated June 15, 1983, were prepared by Tetra Tech, Inc., for FEMA.
Sewall's Point, Town of:	the hydrologic and hydraulic analyses for the FIS report dated October 3, 1983, were taken from the unincorporated areas of Martin County FIS (Reference 1).
Stuart, City of:	the hydrologic and hydraulic coastal analyses for the St. Lucie River were prepared by Dewberry and Davis for the Federal Emergency Management Agency (FEMA). That work was completed in November 1996. Hydrologic and hydraulic coastal analyses for the North Fork St. Lucie River and the South Fork St. Lucie River came from the contiguous Unincorporated Areas of Martin County, Florida (Reference 1).

For the October 2002 countywide FIS, hydrologic and hydraulic and coastal analyses were prepared by Taylor Engineering, Inc., for FEMA, under Contract No. EMA-96-CO- 0022. Schnars, P.A., and Morgan & Eklund, Inc., performed riverine and beach/near shore surveying, respectively, under contract to Taylor Engineering (Reference 2). This work was completed in August 1997.

For this revised countywide FIS, the hydrologic and hydraulic analyses and coastal redelineation were performed by Watershed IV Alliance, for the FEMA, under Contract No. EMA-2002-CO-0011A, Task Order 023. This work was completed in October 2012. Through a join U.S Army Corps of Engineers (USACE) and FEMA effort, Herbert Hoover Dike (HHD) Dike breach analyses and downstream floodplain mapping were performed by Taylor Engineering Inc. (under USACE contract W912EP-06-D-0012) and Watershed IV Alliance (under FEMA Contract EMA-2002-CO-011A, Task Order 018). This work was completed in September 2012.

Base map files were provided from a variety of sources including U.S. Geological Survey, South Florida Water Management District, NOAA, Martin County Information Technology Services, Florida Department of Environmental Protection and U.S. Fish and Wildlife Service. All files were provided in digital format using source material at a scale of 1:24,000 or better. The coordinate system used for the production of the FIRM is State Plane Florida East referenced to the North American Datum 1983 (NAD 83) and GRS 1980 spheroid. Corner coordinates shown on the FIRM are in latitude and longitude.

1.3 Coordination

An initial Consultation Coordination Officer (CCO) meeting (also occasionally referred to as the Scoping meeting) is held with representatives of the communities, FEMA, and the study contractors to explain the nature and purpose of the FIS and to identify the streams to be studied by detailed methods. A final CCO (often referred to as the Preliminary DFIRM Community Coordination, or PDCC, meeting) is held with representatives of the communities, FEMA, and the study contractors to review the results of the study.

For this revision of the countywide FIS, the initial CCO meeting was held on August 13, 2008, and attended by personnel of the Town of Jupiter Island, Town of Seawall's Point, City of Stuart, Town of Ocean Breeze Park, Martin County, FEMA, and South Florida Water Management District (SFWMD). Letters were sent to various State, Federal, and private agencies informing them of the forthcoming insurance study and requesting any pertinent information available.

The final CCO meeting was held on Date, Month, Year to review and accept the results of this FIS. Those who attended this meeting included representatives of Martin County, Watershed IV Alliance, FEMA, and the communities. All problems raised at that meeting have been addressed in this study.

The dates of the historical initial and final CCO meetings held for the communities within the boundaries of Martin County are shown in the following tabulation:

Community Name	Initial CCO Date	Final CCO Date
Martin County (Unincorporated Areas)	August 20, 1979	July 24, 1980
Stuart, City of	*	July 27, 1977
Martin County And Incorporated Areas	September 20, 1995	July 17, 2001

* Data not available

2.0 AREA STUDIED

2.1 Scope of Study

This Flood Insurance Study covers the geographic area of Martin County, Florida.

The following streams were studied by detailed methods for this restudy: Coral Gardens Canal (also referred to as Unnamed Tributary to South Fork St. Lucie River), Danforth Creek, a portion of East Fork Creek, Fern Creek, Manatee Creek, Roebuck Creek, Rowland Canal, Unnamed Tributary 1 to Roebuck Creek and Warner Creek. Detailed study streams are shown in Table 1, "Detailed Study Streams."

Table 1 – Detailed Study Streams

Stream	Reach Limits
Coral Gardens Canal	From confluence with South Fork St. Lucie River to downstream face of Willoughby Boulevard
Danforth Creek	From confluence with South Fork St. Lucie River to approximately 1 mile upstream of SW 48th Avenue/SR 76A
East Fork Creek	From 100 feet upstream of Mariner Sands Drive to approximately 950 feet upstream of SE Constitution Boulevard
Fern Creek	From confluence with South Fork St. Lucie River to downstream face of SE Salerno Road
Manatee Creek	From approximately 550 feet downstream of Cove Road to the downstream face of U.S Route 1

Table 1 – Detailed Study Stream (continued)

Stream	Reach Limits
Roebuck Creek	From confluence with St. Lucie Canal Okeechobee Waterway to approximately 0.8 mile upstream of State Route 76
Rowland Canal	From confluence with St. Lucie Canal Waterway to 0.6 miles upstream of SW 150th Street
Unnamed Tributary 1 to Roebuck Creek	From confluence with Roebuck Creek to SW Old Royal Drive
Warner Creek	From confluence with St. Lucie River to downstream face of NE Jensen Beach Boulevard

Floodplain boundaries of some streams that have been previously studied by detailed methods were redelineated based on more detailed and up-to-date topographic data. Redelineated streams include Bessey Creek, Loxahatachee River, South Fork St. Lucie River, and a portion of East Fork Creek.

All coastal areas were redelineated based on the base flood elevations from the October 2002 FIS report. Computations for flood levels along the rivers subject to either coastal surges or rainfall were independently performed. Coastal surge elevations were combined statistically with riverine (rainfall) flood levels to obtain base flood levels for each return period.

2.2 Community Description

Martin County, located in the southern portion of Florida's east coast, is bordered by St. Lucie County on the north; Okeechobee County on the west; Palm Beach County on the south; and the Atlantic Ocean on the east. The City of Stuart, the county seat, is located approximately 100 miles north of Miami and 120 miles southeast of Orlando. The land area of Martin County comprises approximately 555 square miles with 22 miles of Atlantic Ocean shoreline. Along the eastern side of the county, a continuous line of shallow estuaries separate the county's mainland from its barrier islands. These estuaries include the Indian River and a series of narrow lagoons including Great Pocket, Peck Lake, Hobe Sound, and Jupiter Sound interconnected by the Intracoastal Waterway. St. Lucie Inlet, located in the northeast quadrant of Martin County, serves as the county's only inlet through the barrier islands. Nearby inlets in adjacent counties include Fort Pierce Inlet to the north and Jupiter Inlet to the south. These three inlets serve as the major passages through which Atlantic Ocean tides and hurricane surges propagate into the county's estuaries. Much of the county's western boundaries lie in Lake Okeechobee which covers 96 square miles of the county's area.

Incorporated areas located within Martin County include the City of Stuart, Town of Ocean Breeze Park, Town of Sewall's Point, and Town of Jupiter Island, all located in the eastern portion of the county. Other communities include Hobe Sound, Hutchinson Island, North River Shores, Palm City, Rio, South County, Port Salerno, Jensen Beach, and Tropical Farms in the eastern portion of the county and Indiantown and Port Mayaca in the central and western portions. The county's eastern third supports most of the county's population and the highest concentration of residential and commercial land use. Residential development is heavy along the coastline and interior waterways including the St. Lucie

River, South Fork St. Lucie River, North Fork St. Lucie River, Indian River, and the Intracoastal Waterway. The county's inland area consists primarily of pasture and agriculture, including citrus groves, with an extensive network of irrigation canals. The U.S Census Bureau's 2010 estimate a population of 146,318 for Martin County (Reference 3). Several major transportation routes serve the county including Interstate Route 95; Florida's Turnpike; U.S. Route 1; State Routes A1A, 7, 10, and 76; the Intracoastal Waterway; and the Florida East Coast Railway.

Martin County has a subtropical climate, with long, warm, and humid summers and short, mild winters. The average annual temperature is 74 degrees Fahrenheit (Reference 4). According to the National Oceanic and Atmospheric Administration (NOAA) records for the Martin County Municipal Airport, located in the eastern portion of the county, the average annual precipitation is 57 inches (Reference 5). Over half of this rainfall occurs during the hurricane season. Based on 1936-1984 data, the seasonal distribution of rainfall ranges from a high of 27.4 inches (June - September) to a low of 10.9 inches (December-March).

Low lying, mildly sloping terrain with extensive swamps generally characterizes the terrain of Martin County. Ground elevations on two ridges crossing the central and western portions of the county exceed 29 feet North American Vertical Datum of 1988 (NAVD88), but generally elevations range from 0 to approximately 19 feet NAVD88 (Reference 6). Much of the terrain is covered with somewhat poorly drained soil formations with a high water table. The predominant soils associated with this flat terrain include Pineda and Riviera Fine Sand, Waveland and Immokalee Fine Sand, Wabasso Sand, Oldsmar Fine Sand, and Nettles Sand (Reference 7). The predominant hydrologic soil groups are D and B.

Most of the major waterways lie in the eastern portion of the county. These include the St. Lucie River, South Fork St. Lucie River, North Fork St. Lucie River, Indian River, Loxahatchee River, North Fork Loxahatchee River, and the Intracoastal Waterway. The St. Lucie River drains a major portion of the middle of the county including much of the City of Stuart. Influenced by coastal surge flooding, the St. Lucie River flows into the Indian River (Intracoastal Waterway) near St. Lucie Inlet. Smaller streams in the eastern portion of the county include Roebuck Creek, Manatee Creek, East Fork Creek (a Manatee Creek tributary), Bessey Creek, and Danforth Creek (interconnected with Bessey Creek).

2.3 Principal Flood Problems

Flooding in Martin County results from tidal surge associated with a northeaster, hurricane, or tropical storm activity and from overflow of streams and swamps associated with rainfall runoff. Major rainfall events occur from hurricanes, tropical storms, and thundershowers associated with frontal systems. Some of the worst area floods were the result of high intensity rainfall during hurricanes or tropical storms.

Having a relatively short time of concentration, the smaller streams tend to reach peak flood flow concurrently with elevated tailwater conditions associated with the coastal storm surge. This greatly increases the likelihood of inundation (observed on several occasions) of low lying areas along the coast. Areas along the Indian River are particularly vulnerable to this flooding. In the eastern portion of the county, most of the flood-prone areas feature poorly drained soil, a high water table, and flat terrain. These characteristics contribute significantly to flooding problems. Furthermore, the flat slopes and heavily vegetated floodplains promote backwater effects and aggravate the flood problems by preventing the rapid drainage of floodwaters.

Good quality, long-term stream gauge data are limited for most study reaches within Martin County. Also, only limited surveyed and verifiable high water marks (HWMs) were available at the time of this revised study. From an October 1995 rainfall event, a surveyed high water mark of 7.65 feet NAVD (9.05 feet NGVD) was recorded on a house adjacent to the South Fork St. Lucie River. Anecdotal evidence of flooding in Bessey Creek during the October 1995 storm was provided by local residents. Additionally, Martin County collected high water marks along Danforth Creek and Bessey Creek from the August 2012 Tropical Storm Issac event.

The coastal areas of Martin County are subject to flooding from tidal surges associated with hurricanes and northeasters. Waves, associated with wind-generated surges, can exacerbate flooding, erode shorelines, and produce high forces which can further damage structures, particularly along the open coastline. Interior areas are also subject to surge flooding and wave damage due to the close proximity of three ocean inlets. Brief descriptions of major storms in the Martin County area follow.

Hurricane of September 6-20, 1928

Originating near the Cape Verde Islands, this major hurricane moved inland on September 16. Its center entered the Florida coast near the City of Palm Beach, and crossed the Lake Okeechobee region with little diminution in intensity. The minimum barometric pressure at West Palm Beach, 928.9 millibars (27.43 inches), was one of the lowest ever recorded in the United States during a hurricane. In the Lake Okeechobee region, the great loss of life and the damage to property were caused by the overflowing of the lake along the southwestern shore.

The total number of deaths in Florida numbered 1,836 and the injured numbered 1,870. Nearly all loss of life occurred in the Lake Okeechobee area; 1,700 people lost their lives in Palm Beach County. Twenty-six dead and 1,437 injured were reported in the West Palm Beach area (from the Town of Jupiter to the City of Delray Beach). Tides of 9.8 feet at Palm Beach and 8 feet at West Palm Beach (Lake Worth) were reported. Property damage, greatest at Lake Worth and the beaches, was estimated at $25 million. There was considerable erosion on Jupiter Island, and other wave damage was reported along the entire length of Indian River.

Hurricane of August 31-September 7, 1933

This major hurricane, which was first detected northeast of Puerto Rico, entered the east coast of Florida on September 4. Its center passed over Jupiter Met where the barometric pressure fell to 947.5 millibars (27.98 inches). Maximum winds were estimated to be 1 10 knots. There was considerable property damage in Florida, mostly in the area between Jupiter and the City of Fort Pierce. Severe waterfront damage was reported at Stuart in Martin County.

Flood of 1947

This flood is generally considered to be the most severe flood recorded in southern Florida, and was exceptional in duration as well as intensity. Heavy rainfall, including high-intensity rainfall from two hurricanes, occurred over a 5-month period. This amounted to more than the average rainfall in some parts of the county. Many parts of the county were flooded for month. While there was extensive damage to dairy pastures and other development, no reliable estimate of damage in Martin County is available. A recurrence of the 1947 flood would cause much more significant damage because of the subsequent increase in development.

Hurricane of August 23-31, 1949

By the time this tropical storm passed north of the Bahama Islands on August 26, it had developed into a full fledged hurricane. Its center entered the east coast of Florida over the Palm Beach-Delray Beach area, with the lowest barometric pressure of 954.0 millibars (28.17 inches) and winds estimated at 113 knots. As the hurricane moved inland, its center passed over the northern part of Lake Okeechobee. This was the worst hurricane in that area since the disastrous hurricane of September 1928. However, the levees held and no flooding occurred. Damage in Florida was estimated at $45 million. Tides of 1 1.3 feet at Fort Pierce, 8.5 feet at Stuart (St. Lucie River), and 6.9 feet at West Palm Beach (Lake Worth) were reported. Stuart sustained severe damage. Over 500 persons were made homeless. The hurricane of August 23-31, 1949, resulted in storm surge elevations of 8.5 feet NGVD in the St. Lucie River (Reference 1).

Flood of 1953

This flood was similar to the 1947 flood, with a heavy 5-month rainfall which included a tropical storm in October. The June through October rainfall was approximately 48 inches. Damage was greater than for the 1947 flood because of greater development. The heaviest damage occurred in the beef cattle industry, with considerable damage to improved pastureland, causing loss of weight to cattle, and requiring supplemental feeding. Truck crop farms and dairy pasture also sustained extensive damage. There was significant damage to the Town or Indiantown; however, it was small compared to agricultural losses in the county.

September 1960 (Tropical Storm Florence)

Tropical Storm Florence was the main cause of flooding in Martin County in 1960. September 21 through 25, rainfall averaged 10 to 11 inches over the county. For a 5-day rainfall, that would be a frequency of occurrence of approximately once in 15 years. However, on the basis of several months duration, the total rainfall was not comparatively as high and the overall frequency of the 1960 flooding was approximately once in 5 years. The most severely damaged section of the county was the Allapattah Marsh area north of St. Lucie Canal, where dike systems failed on several ranches. On September 17, 1960, 5.2 inches of rain fell in 24 hours. September 1960 totaled 24.9 inches.

October 1964 (Hurricane Isabell)

Hurricane Isabell entered the coast of Florida near Everglades and proceeded northeasterly until it exited from the Jupiter area. A minimum pressure of 28.88 inches and winds reaching 90 miles per hour occurred. Tidal damage was minor. Streets in low-lying portions of the Hobe Sound area were reportedly covered with water resulting from torrents of rain. On October 1, 1964, 7.0 inches of rain fell in 24 hours while 15.2 inches fell for the month.

August 17 - August 21, 1976 (Tropical Storm Dottie)

Tropical Storm Dottie originated in the Gulf of Mexico and traveled east before making landfall in southwest Florida near Flamingo. The storm then crossed over the Florida peninsula, commenced a more northerly direction and moved over the Atlantic Ocean near Martin County. Minor beach erosion and flooding resulted. Damage estimates in southeast Florida associated with this storm were minimal.

August 25 - September 7, 1979 (Hurricane David)

Hurricane David made landfall on September 3, 1979, in Martin County and skirted the entire east coast of Florida. Significant structural damage to residential and commercial properties resulted from Hurricane David. There was also significant beach erosion and coastal flooding damage in Martin County. Storm-related damages in Florida were approximately $80 million (Reference 8).

August 7 - August 21, 1981 (Tropical Storm Dennis)

Dennis crossed over the Florida Keys and made landfall as a Tropical Storm in southwest Florida near Flamingo. The storm then moved north up the Florida Peninsula and was located at approximately 100 miles to the west of Jupiter Island at its closest proximity. Only minor flooding from rainfall was reported. Beach erosion and residential and commercial structure damage was minimal. Storm related damages in southeast Florida were approximately $25 million.

September 25 - October 1, 1984 (Tropical Storm Isidore)

Isidore made landfall as a Tropical Storm in Jupiter, passing near Hobe Sound and Stuart, on September 27, 1984. Coastal flooding and beach erosion as well as some structural damage to residential and commercial structures was reported. Property damage is estimated to be $1 million in southeast Florida.

July 31 - August 6, 1995 (Hurricane Erin)

Hurricane Erin made landfall to the north of Martin County near Vero Beach, Florida, on August 2, 1995. The storm then crossed over the Florida Peninsula and made landfall again near Pensacola, Florida (Reference 9). Coastal erosion was limited to dune retreat and minor flooding. Damages to residential and commercial properties in southeast Florida exceeded $200 million.

October 1995 Rainfall Event

On October 18, 1995, 16.1 inches of rain fell in a 24 hour period. This intensity exceeds that of a 100-year event, an event with a 1 percent-chance of annual exceedence (Reference 9). The monthly total for October 1995 was 24.5 inches.

September 7 - September 17, 1999 (Hurricane Floyd)

Hurricane Floyd passed approximately 120 miles to the east of Martin County on September 14, 1999, as a Category 4 hurricane (Reference 10). The storm paralleled nearly the entire east coast of Florida for approximately 150 miles. Minimal storm surge (approximately 2 feet) and maximum winds of 50 mph (sustained winds of approximately

40 mph) in Martin County resulted in beach erosion and minor damage to residential and commercial structures.

August 19, 2008 (Tropical Storm Fay)

Tropical Storm Fay impacted Martin County and adjacent communities on August 19, 2008. The National Weather Service official storm rainfall totals for various locations throughout Martin County ranged from 9 inches in Hobe Sound to greater than 15 inches in North Stuart. Tropical storm rainfall exceeding 24 inches was measured by the National Weather Service near Martin County. The excessive rainfall over a short duration overwhelmed many drainage systems. As a result widespread flooding occurred on roads and private property while the drainage systems recovered. This condition was exacerbated by high ground water tables and standing water in low-lying areas before the storm due to by higher than average rainfall totals along the coastline during the summer months The major affected areas were Jensen Beach, Golden Gate/Port Salerno Area, Hobe Sound Area, Old Palm City, Palm City Farms, and Indiantown area. Flooding was also reported in Warner Creek, Haney Creek, and the Coral Gardens Canal drainage basins (Reference 11).

August 25 – August 30 (Tropical Storm Issac)

Tropical Storm Issac impacted Martin County by producing sustained wind of 20 to 25 miles per hour with gusts to 35 to 40 miles per hours and by dumping rainfall varying from 3 to 7 inches in a 24-hour period within the county boundary. Martin County officials surveyed high water marks along various places within the county especially in Danforth and Bessey Creek watersheds. A high water mark of 16.1’ NAVD88 was measured at Leighton Farms Road along Danforth Creek (Reference 12).

2.4 Flood Protection Measures

Flood protection measures within Martin County include the Herbert Hoover Dike system and its associated flood gates which were designed and constructed in the 1950s to provide protection from hurricane surge and high water-surface levels on Lake Okeechobee. The Herbert Hoover Dike and floodgate system is operated and maintained by the USACE. The adjacent western Martin County areas are generally protected from high frequency event flooding by the Herbert Hoover Dike. Presently, the Herbert Hoover Dike cannot be certified by the USACE as being capable of providing flood protection during prolonged periods of high lake levels of Lake Okeechobee, or during the 1-percent-annual-chance flood event. The overall stability of the Herbert Hoover Dike system is currently being evaluated by the USACE to determine the extent of possible structural repairs and rehabilitation necessary to provide more adequate flood protection. The dike system affecting Martin County has been evaluated by the USACE (References 13, 14 and 15). Based on the evaluation completed to date, the USACE has determined that, until the structural repairs and rehabilitation of the Herbert Hoover Dike are completed, the adjacent low-lying floodplains and communities along the eastern reaches of the dike may be subject to flood inundation from Lake Okeechobee as a result of structural failure and breaching of the dike due to piping and seepage. Through a separate study, jointly funded by the USACE and FEMA (Reference 16 and 17), the affected areas subject to this potential flood hazard have been identified as described in Section 3.2. The resulting 1-percent-annual-chance-flood zones have been delineated and labeled on the FIRM for Martin County as part of this study.

In addition to the Herbert Hoover Dike, there are other flood control canals, locks, and pump stations near Lake Okeechobee, and in numerous other locations within Martin

County which are operated and maintained by the SFWMD. Along the shorelines of the Atlantic coast and inland rivers and sounds, there are numerous individual seawalls and bulkheads that provide protection for private property but do not provide a one-percent-annual chance flood protection capacity. A federally sponsored (USACE) and maintained beach nourishment project is located along a 5-mile reach on Hutchinson Island along the Atlantic Ocean coastal shoreline from the northern county limits to just south of the Stuart Beach Public Park. The beach nourishment project is co-sponsored by the State of Florida and Martin County, but is not designed to provide protection during the 1-percent-annual-chance flood.

Other non-structural floodplain management measures within the county are exercised. These include county zoning ordinances, building codes designed to reduce flood damage, and hurricane advisories and emergency plans. Flooding problems in the Danforth Creek, Fern Creek, Manatee Creek and Warner Creek basin have led the county to implement structural and non-structural channel modifications to mitigate flooding problems. Available information concerning these flood protection measures were evaluated and incorporated into this countywide FIS, where appropriate.

3.0 ENGINEERING METHODS

For the flooding sources studied in detail in the community, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this study. Flood events of a magnitude that is expected to be equaled or exceeded once on the average during any 10-, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for floodplain management and for flood insurance rates. These events, commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10-, 2-, 1-, and 0.2-percent chance, respectively, of being equaled or exceeded during any year. Although the recurrence interval represents the long-term average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than 1 year are considered. For example, the risk of having a flood that equals or exceeds the 100-year flood (1-percent chance of annual exceedence) in any 50-year period is approximately 40-percent (4 in 10), and for any 90-year period, the risk increases to approximately 60-percent (6 in 10). The analyses reported herein reflect flooding potentials based on conditions existing in the community at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

3.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish the peak discharge-frequency relationships for each flooding source studied by detailed methods affecting the community.

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Stream gage records for the Loxahatchee River were statistically analyzed utilizing the standard log-Pearson Type III distribution as recommended by the U.S .Water Resources Council (Reference 18). Stream gage information for the Loxahatchee River was obtained from gage No. 227700 on the river near Jupiter; the gage has been in operation since 1971.

The USACE HEC-1 computer program was used to estimate the desired discharge frequency relationships for Bessey Creek, South Fork St. Lucie River and East Fork Creek

(Reference 19). This methodology was appropriate for the characteristic drainage basin conditions. Furthermore, the limited history of stream gauge records for these streams precluded effective statistical analysis. The HEC-1 modeling incorporated the SCS unit hydrograph and kinematic wave routing methods. Parameters supplied to the model of each stream included subbasin runoff curve numbers, lag times, stream cross sections, and Manning's "n" roughness factors. Curve numbers were calculated using the SCS curve number methods based on Florida DOT aerial photographs at a scale of 1:25,000, and GIS soils and land use coverages (References 20-22). Lag times were calculated using the empirical SCS curve number formula (Reference 23). Calibration of the HEC-1 models for each study area was not performed due to a lack of sufficient stream gauge data. Existing HEC-1 model setups were used with some modifications for the Bessey Creek basin (Reference 24). The HEC-1 models were used to estimate peak discharges for the 10-, 2-, 1- and 0.2-percent-annual-chance exceedance floods for South Fork St. Lucie River, Loxahatchee River and East Fork Creek. For Bessey Creek, the HEC-1 model was used to estimate peak discharges for the 1- and 0.2-percent-annual-chance exceedance flood events. For each storm events, total storm rainfall amounts were based on the TP-40 rainfall frequency atlas for a 24-hour storm duration (Reference 25).

This Countywide Restudy Analysis

For this countywide restudy, hydrologic analyses for Bessey Creek, Loxahatchee River, South Fork St. Lucie River and the downstream portion of East Fork Creek were adopted from the October 2002 FIS study. Also detailed hydrologic calculations for Danforth Creek, Manatee Creek, and Roebuck Creek were revised using the Integrated Channel and Pond Routing (ICPR) program (Reference 26). New studies were performed for Fern Creek, Unnamed Tributary 1 to Roebuck Creek, and Warner Creek using ICPR program. Martin County provided ICPR models for Danforth Creek, Fern Creek, Manatee Creek, Roebuck Creek and Warner Creek. Martin County’s engineering consultant, CAPTEC Engineering Inc, created ICPR models for these five streams as part of County’s stormwater management plan for each of these streams (References 27-31). These stormwater management plans included construction of flood control structures and other basin wide drainage improvements. As of September 2012, Martin County had substantially finished the construction of the flood control structures within the watersheds of these five streams.

ICPR model is a one dimensional hydro-dynamic model simulates hydrology and hydraulics and estimates the flow and stages for the simulated duration at model nodes along the stream. For each of the five streams, CAPTEC Engineering Inc. developed a ICPR model that incorporated the flood control improvements. All ICPR models were reviewed and approved by SFWMD during the permitting phase for the construction of the flood control improvements. The ICPR models applied SCS methodology to simulate the hydrology for each stream.

Total rainfall depths were derived by interpolating available data from the SFWMD for 10-, 2-, 1- and 0.2-percent-annual-chance exceedance 24-hr storms. These depths correspond to 7.1, 10.4, 11.8, and 15.1 inches, respectively (Reference 32). For Danforth Creek, Manatee Creek, Roebuck Creek and Unnamed Tributary 1 to Roebuck Creek, the ICPR model applied a 24-hour design storm duration to estimate stream flows for the 10-, 2-, 1- and 0.2-percent-annual-chance exceedance storm events.

For Fern Creek and Warner Creek, the model considered a 72 hour design storm event (based on SFWMD’s permit manual)to estimate flows for the 10-, 2-, 1- and 0.2-percent-annual-chance exceedance storm events (Reference 33). For internal boundary conditions, the ICPR models for Fern Creek and Warner Creek uses the permitted flows from a 72-hour storm event for a few basins that represent housing sub-divisions. Therefore, the Fern Creek and Warner Creek models peak flows are based on a 72-hour storm event. Total rainfall depths derived by interpolating available data from the SFWMD for 10-, 2-, 1- and 0.2-percent-annual-chance exceedance 72-hour storms were 9, 12, 14, and 18.1 inches, respectively (Reference 33). Minor adjustments were made to these ICPR models to reflect the latest rainfall depths and unit hydrograph's peak factor of 284. For each stream, the ICPR model provided peak flows for the 10-, 2-, 1- and 0.2-percent-annual-chance exceedance 24-hour storm events.

For Coral Gardens Canal, East Fork Creek and Rowland Canal, frequency-discharges were developed using the USACE HEC-HMS computer program (Reference 34). The basins for each stream were divided into sub-areas, and synthetic unit hydrographs were developed for each sub-area using SCS methodology. Curve Numbers (CN) and time of concentrations (Tc) were calculated using the SCS method based on topography, soil, and land cover data (Reference 35-36). Rainfall losses for all basins were based on SCS CN loss rates. Where applicable, HEC-HMS models incorporated storage areas within each basin to attenuate the flow from different rainfall events. Storage areas were delineated based on the terrain and aerials. The stage-storage volume relationships for these storage areas were obtained by analyzing the terrain and using engineering judgment.

The HEC-HMS model considered the Delmarva Unit Hydrograph precipitation and SCS Florida Modified Type II distribution. Hydrograph routing in the main channel was computed using the Muskingum-Cunge method. Eight point cross-sections were used for each subbasin reach and were based on available surveyed cross section data. For Coral Gardens Canal and East Fork Creek, the HEC-HMS model provided peak flows for the 10-, 2-, 1- and 0.2-percent-annual-chance exceedance 24-hour storm events. For Rowland Canal, the HEC-HMS model provided peak flows for the 1-percent-annual-chance exceedance 24-hour storm event only.

A summary of the drainage areas and peak discharge relationships for all streams studied by detailed methods is shown in Table 2, "Summary of Discharges."

Table 2 – Summary of Discharges

		Peak Discharges (cubic feet per second)			
Flooding Source and Location	Drainage Area (square miles)	10-Percent-Annual-Chance	2-Percent-Annual-Chance	1-Percent-Annual-Chance	0.2-Percent-Annual-Chance
Bessey Creek					
At Murphy Road	10.39	*	*	2,441	3,276
At Boat Ramp Avenue	4.93	*	*	1,114	1,729
At SE Norfolk Boulevard	2.83	226	428	537	818
At Willoughby Road	2.44	203	398	497	714

Table 2 – Summary of Discharges (continued)

Flooding Source and Location	Drainage Area (square miles)	Peak Discharges (cubic feet per second) 10-Percent-Annual-Chance	2-Percent-Annual-Chance	1-Percent-Annual-Chance	0.2-Percent-Annual-Chance
Coral Gardens Canal					
Confluence with South Fork St. Lucie River	3.44	263	533	665	1000
At SE Norfolk Boulevard	2.83	226	428	537	818
At Willoughby Road	2.44	203	398	497	714
Danforth Creek					
At confluence with South Fork St. Lucie River	6.00	832	1,232	1,391	1,761
At State Highway 714	5.21	653	805	864	1022
At SW 48th Avenue	2.92	355	440	516	690
East Fork Creek					
At State Route A1A **	3.48	487	696	802	1,133
At Mariners Sand Drive **	2.93	467	677	780	1,098
At Lexington Avenue	0.45	269	373	423	585
Fern Creek					
At State Highway 76	1.86	286	417	453	595
At SE Salerno Road	0.69	144	183	190	210
Loxahatchee River					
At County Boundary	55.0	2,857	4,189	4,771	6,155
Manatee Creek					
At SE Dixie Highway	1.24	288	448	505	621
At SE Highway 1	0.74	142	194	217	273
Roebuck Creek					
At Confluence with St. Lucie Canal	3.01	460	750	868	1,142
At SW Locks Road	1.91	344	539	619	767
At SW Mary Drive	0.61	138	212	221	252
Rowland Canal					
At State Highway 710	3.24	*	*	1,142	*

Table 2 – Summary of Discharges (continued)

Flooding Source and Location	Drainage Area (square miles)	Peak Discharges (cubic feet per second) 10-Percent-Annual-Chance	2-Percent-Annual-Chance	1-Percent-Annual-Chance	0.2-Percent-Annual-Chance
Rowland Canal (contd)					
At Confluence with St. Lucie Canal	4.07	*	*	1,393	*
South Fork St. Lucie River					
At State Route 76	33.4	1,970	2,899	3,314	4,515
Unnamed Tributary 1 to Roebuck Creek					
Confluence with Roebuck Creek	0.38	49	80	97	135
Warner Creek					
At Confluence with St. Lucie River	8.02	564	843	900	1,110
At NE Pinelake Village Boulevard	7.28	470	670	711	867
At NE Jensen Beach Boulevard	5.48	290	369	380	444

* Data not available
** Data obtained from October 2002 FIS

3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of flooding from the source studied were carried out to provide estimates of the elevations of floods of the selected recurrence intervals. Users should be aware that flood elevations shown on the FIRM represent rounded whole-foot elevations and may not exactly reflect the elevations shown on the Flood Profiles or in the Floodway Data tables in the FIS report. For construction and/or floodplain management purposes, users are encouraged to use the flood elevation data presented in this FIS in conjunction with the data shown on the FIRM.

October 4, 2002 FIS Countywide Study

For the Loxahatchee River, water-surface elevations of floods of the selected recurrence intervals were computed using the USACE HEC-2 step-backwater computer program (Reference 38). Starting water-surface elevations were taken from the mean high tide elevations of the Atlantic Ocean. Roughness factors (Manning’s "N") used in the hydraulic computations were chosen by engineering judgment and were based on field inspection of the floodplain areas and are shown below.

Cross sections were obtained from field surveys supplemented with the 1:2,400 scale aerial photographs with 1 foot contour intervals covering the Bessey and Danforth Creek basin and the South Fork St. Lucie River basin and the 1:24,000 scale USGS topographic maps (References 37 and 38). Surveys were tied into U.S. Coast and Geodetic Survey and FDOT benchmarks. Cross section and bridge data for crossings over Bessey and Danforth Creeks (not included in the existing model setup) were taken from FDOT bridge plans supplemented by field survey (Reference 39). Also based on field surveys, cross section and bridge data for the South Fork St. Lucie River were provided by the SFWMD (Reference 40).

Water-surface elevations of floods of the selected recurrence intervals were computed using the USACE UNET and HEC-2 water-surface profile computer programs (References 41-43). An unsteady, channel network (split-flow) hydraulic model based on the one-dimensional equations of motion, UNET was applied to two streams, Bessey Creek and Danforth Creek, comprising an interconnected system. For this system, an existing model setup, with necessary modifications, was applied to compute the peak water-surface elevations associated with the 1- and 0.2-percent-annual-chance exceedance storm events (Reference 44). Based on the one-dimensional energy equation and standard step computation method, HEC-2 was applied to four streams, East Fork Creek, Manatee Creek, Roebuck Creek, and South Fork St. Lucie River. Mean high tide elevations were used as starting water-surface elevations for Roebuck Creek, East Fork Creek, and Manatee Creek. The FDEP provided these values (Reference 45). The fiction-slope method was used as the starting water surface elevation for South Fork St. Lucie River. For Bessey and Danforth Creek, the starting water-surface elevations established for the existing model setups were used (References 24, 46, 47).

This Countywide Restudy Analysis

For this countywide restudy, hydraulic analyses for Bessey Creek, Loxahatchee River, South Fork St. Lucie River and portion of East Fork Creek (from the confluence with Manatee Creek to Mariner Sands Drive) were adopted from the October 2002 FIS study. For Coral Gardens Canal, East Fork Creek from Mariner Sands Drive to 950 feet upstream of SE Constitution Boulevard, Roebuck Creek, and Rowland Canal water-surface elevations from the selected recurrence intervals were computed using the USACE HEC-RAS step-backwater computer program (Reference 48). For starting water surface elevations, backwater computations began at normal depth for all streams except East Fork Creek. For East Fork Creek, starting water surface elevations at a point 100 feet upstream of Mariner Sands Drive were obtained from the October 2002 FIS study. The HEC-HMS models provided the 10-, 2-, 1- and 0.2-percent-annual-chance exceedance storm peak flows for Coral Gardens Canal, and East Fork Creek. For Roebuck Creek, the peak flows for the 10-, 2-, 1- and 0.2-percent-annual-chance exceedance storm peak flows were obtained from Martin County's ICPR model. For Rowland Canal, only the 1-percent-annual-chance exceedance peak flow was used in the HEC-RAS model. Flood profiles were drawn showing computed water-surface elevations of floods of the selected recurrence intervals.

Cross section geometries were obtained from a combination of digital terrain data provided by Martin County and field surveys. For most detailed study streams, all bridges and culverts were either field surveyed to obtain elevation data and structural geometry or were obtained from as-built drawings. Selected cross sections were field surveyed along the streams to determine channel geometries between bridges and culverts. For the Roebuck Creek HEC-RAS model, the channel and structure data was copied from the October 2, 2002 FIS study HEC-2 model. All channel data was supplemented with available LiDAR data for overbank topography. LiDAR data was unavailable for the entire length of Rowland Canal, a portion of Danforth Creek upstream of the Florida Turnpike and a portion of Roebuck Creek upstream of SW96th Street. For the areas without LiDAR data, Martin County provided limited spot elevation datasets.

The Rowland Canal HEC-RAS model was developed using spot elevation data and surveyed channel data. Only the 1-percent-annual-chance exceedance storm event elevations was simulated in the HEC-RAS model.

As stated in section 3.1, Martin County provided one-dimensional hydrodynamic ICPR models representing flood control improvements in Danforth Creek, Fern Creek, Manatee Creek and Warner Creek. These ICPR models were reviewed and approved by Martin County and SFWMD.

Locations of selected cross sections and nodes used in the hydraulic analyses are shown on the Flood Profiles and on the Flood Insurance Rate Map.

Manning's roughness coefficients (Manning's "N") for these computations were assigned on the basis of field inspection of the flood plain areas. Roughness coefficients for the streams studied in detail are contained in Table 3, "Manning's N Values."

Table 3 –Manning's N Values

Stream	Channel	Overbank
Bessey Creek	0.035 – 0.05	0.12-0.2
Coral Gardens Canal	0.04	0.06 – 0.15
Danforth Creek	0.035 -0.04	-
East Fork Creek	0.03	0.05
Fern Creek	0.022- 0.05	-
Loxahatchee River	0.035	0.1
Manatee Creek	0.035	0.1
Roebuck Creek	0.04 – 0.06	0.06 – 0.1
Rowland Canal	0.03	0.05 – 0.15
South Fork St. Lucie River	0.035 – 0.04	0.1
Unnamed Tributary 1 to Roebuck Creek	0.045 – 0.06	0.08 - 0.1
Warner Creek	0.02 – 0.045	-

The hydraulic analyses for this study were based on unobstructed flow. The flood elevations shown on the Flood Profiles (Exhibit 1) are thus considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail.

A study was conducted to estimate the 1-percent-annual-chance flood elevations downstream of the unaccredited Herbert Hoover Dike (HHD or Dike) surrounding Lake Okeechobee. The state-of-the-art study approach, consistent with FEMA's Guidelines and Specifications, Analysis and Mapping Procedures for Non-Accredited Levees (revised), and coastal surge study methodologies, incorporated a Technical Steering Committee including Messrs. Donald Resio, PhD and Arthur Miller, PhD, P.E.

The study of HHD failure and associated flood risks comprised three major tasks: (1) an analysis of stage-frequencies for lake water levels, (2) establishment of dike fragility curves for each dike reach, and (3) joint probability analyses of downstream flood inundations created by various dike breach scenarios (11 breach locations and 8 lake water levels). For a given water level behind the dike, task 1 established the frequency of occurrence of the water level, and task 2 established the associated dike failure probability. Considering these probabilities, along with the results of the model simulations for various lake level breaches, task 3 established the joint probability of HHD failure (failure rate at each breach location) and corresponding probability of downstream flood elevations associated with dike breaching. The 1999 USACE Herbert Hoover Dike Major Rehabilitation Evaluation Report, called the MRR, provided the critical lake stage-frequency curve and dike fragility curves representing each reach (breach location) around HHD (Reference 16). A 2011 USACE study performed by Taylor Engineering provided the advanced, two-dimensional hydrodynamic dam breach model (MIKE modeling system) to simulate breaches and the associated downstream flooding caused by seepage/piping and slope stability (Reference 17). (This study did not address alternative mechanisms of failure such as overtopping.) Because the USACE's main study goal was part of emergency planning, rather than mitigation and flood insurance rate map production, this study included additional activities aimed at estimating 1-percent-annual-chance flood elevations, including additional hydrodynamic simulations and statistical analyses.

A component of the statistical analyses, Figure 1 illustrates the calculated HHD failure rate (events per year) for lake levels from 14 feet to 21 feet, NAVD datum.

Note the calculated failure rates in the figure apply to the total dike system (i.e., the total dike failure rate at a given lake level represents the combined failure rate of all reaches). Each dike reach around the circumference of the lake must receive a portion of the total failure rate. Because the dike comprises 11 reaches with an established fragility curve for each reach based on characteristic geotechnical conditions for that reach, the failure probability of each reach provides the basis to allocate (through Equation 1) the total failure rate.

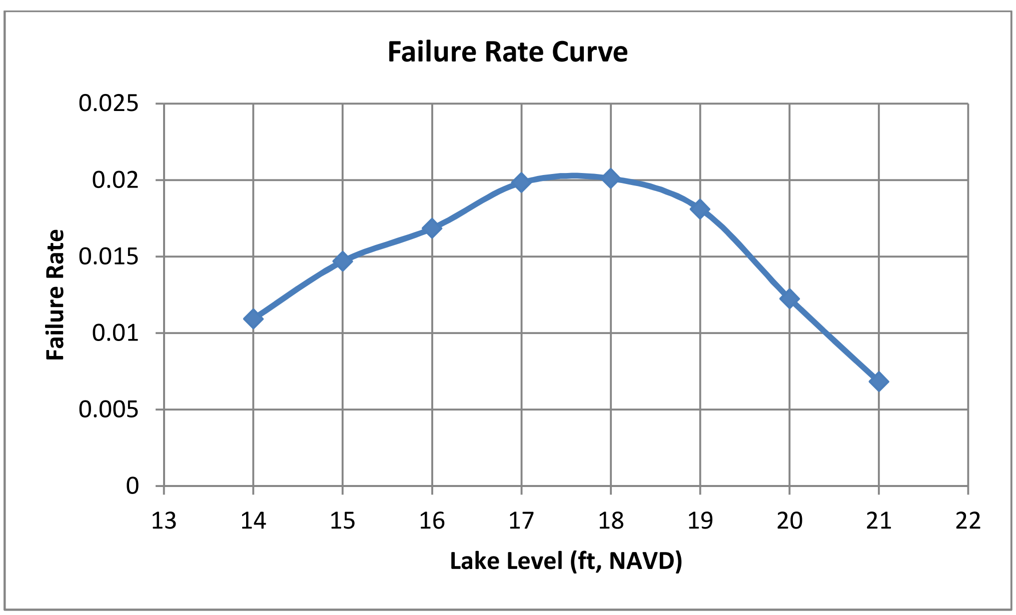

Figure 1 – HHD Failure Rate (Events per Year) for Various Lake Okeechobee Lake Levels

Note the calculated failure rates in the figure apply to the total dike system (i.e., the total dike failure rate at a given lake level represents the combined failure rate of all reaches). Each dike reach around the circumference of the lake must receive a portion of the total failure rate. Because the dike comprises 11 reaches with an established fragility curve for each reach based on characteristic geotechnical conditions for that reach, the failure probability of each reach provides the basis to allocate (through Equation 1) the total failure rate.

$$Rate_{i,j} = \frac{P_{i,j}}{\sum_{i=1A..}^{8} P_{i,j}} \times TotalRate_j \qquad (1)$$

Here, i denotes the reach number from 1A to 8; j denotes the lake level from 14ft to 21ft; $Rate_{i,j}$ is occurrence rate of each breach; $TotalRate_j$ is the total dike failure rate.

Table 4 shows the rate for each breach simulation. Note the MRR fragility curves indicate a 100 % chance of failure at a lake level of 20 feet NAVD somewhere along HHD; therefore, the allocated rates for all reaches at 21 feet (from Equation 1) are combined into the allocated rates at 20 feet in Table 4, and the allocated rates for 21 feet are set to zero.

Table 4 – Allocated Failure Rate (Events per Year) for each Breach Simulation

	Lake Level (NAVD Datum)							
Reach	14 feet	15 feet	16 feet	17 feet	18 feet	19 feet	20 feet	21 feet
1A	0.000117	0.000157	0.000181	0.000266	0.001551	0.001585	0.001925	0
1B	0.000117	0.000157	0.000181	0.000266	0.001351	0.001375	0.001724	0
1C	0.003464	0.004644	0.005321	0.007578	0.004713	0.003815	0.003712	0
2	0.003892	0.00523	0.006028	0.004256	0.00377	0.003318	0.003389	0
3	0.002997	0.004027	0.004642	0.004965	0.004271	0.003737	0.003761	0
4	3.89E-05	5.23E-05	6.03E-05	8.87E-05	0.000184	0.000179	0.000209	0
5	3.89E-05	5.23E-05	6.03E-05	8.87E-05	0.000184	0.000179	0.000209	0
6A	1.56E-05	2.09E-05	3.01E-06	4.61E-05	7.54E-05	7.21E-05	8.36E-05	0
6B	2.34E-05	3.14E-05	4.52E-06	7.09E-05	0.000117	0.000112	0.000131	0
7	0.000195	0.000261	0.000301	0.002114	0.003701	0.003562	0.003728	0
8	3.89E-05	5.23E-05	6.03E-05	8.87E-05	0.000184	0.000179	0.000209	0

Applied to the breach flooding simulation results, the statistical analysis yielded a statistical flood surface, which represents flood levels at every computational node for a given flood frequency, in this case the 1-percent-annual chance. The statistical surface then became the basis for work maps that show the extent of 1 percent-annual chance flooding, proposed Base Flood Elevations, and proposed Special Flood Hazard Area zones. A detailed report (Reference 17) documents the study approach and results. Engineering and mapping products are consistent with FEMA's Guidelines and Specifications and the study's scope of work.

Revised Zone AEs, from the above results, were mapped where appropriate. In areas that do not reach the 1 percent-annual chance flood level, Zone X-Shaded was mapped using the simulated flood inundation from a breach with an initial lake level of 20 feet NAVD. Also, some Special Flood Hazard Areas remained unchanged depending on the location and flooding source, and Zone A's were mapped where the 1-percent-annual chance flood level was not determined due to lack of modeling data (breach location limitations).

The study also included coordination with stakeholders, specifically the USACE, South Florida Water Management District, and local communities. Leveraging existing studies and reports, including the USACE's HHD breach model and MRR, also proved critical to the cost-effective and timely completion of this scope of work. The USACE authorized the use of its HHD hydrodynamic breach model in May 2011 as the foundation for this study and provided other supporting insight, information, and clarification about the MRR data, Lake Okeechobee water levels and regulation, and ongoing HHD improvements.

3.3 Coastal Hydrologic Analyses

Coastal hydrologic analyses, the determination of storm surge elevations, were carried out during the 1983 Flood Insurance Study (Reference 1) to establish the peak elevation-frequency relationship for floods of the selected recurrence intervals for each flooding source studied in detail affecting the county. These same storm surge elevations have been used for all subsequent studies.

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Stillwater elevations for hurricane surges with 10-, 50-, 100-, and 500-year return periods were determined by Tetra Tech, Inc., for the Atlantic Ocean at the open coast, Indian River, St. Lucie River, North and South Forks St. Lucie River, Intracoastal Waterway, Hobe and Jupiter Sounds, North and Northwest Forks Loxahatchee River, and Lake Okeechobee, were determined by the joint probability method (Reference 1). The storm populations were described by probability distributions of five parameters which influence surge heights. These were central pressure depression (which measures the intensity of the storm), radius to maximum winds, forward speed of the storm, shoreline crossing point, and crossing angle. These characteristics were described statistically based upon an analysis of observed storms in the vicinity of Martin County; primary sources of data for this were the National Climatic Center, Cry, Ho, Schwerdt, and Goodyear, the National Hurricane Research project, and the Monthly Weather Review (References 49-52). Digitized storm information for all storms from 1886 through 1977 was used to correlate statistics (Reference 53). Summaries of the parameters used for the Martin County coastal area and Lake Okeechobee are presented in Tables 5 and 6, respectively, "Parameter Values for Surge Elevation."

For areas subject to hurricane-surge flooding, the Flood Insurance Agency (FIA) standard coastal surge model was used to simulate the coastal surge generated by any chosen storm (that is, any combination of the five storm parameters defined previously). Performing surge simulations for a large number of storms, each of known total probability, permits one to establish the frequency distribution of surge height as a function of coastal location. These distributions incorporate the large-scale surge behavior but do not include an analysis of the added effects associated with much finer scale wave phenomena such as wave height, setup, and runup. As the final step in the calculations, the astronomical tide for the region is statistically combined with the computed storm surge to yield recurrence intervals of total water level (Reference 54).

The storm surge model utilized a grid pattern approximating the geographical features of the study area and the adjoining areas to simulate flooding effects of hurricanes. Surges were computed utilizing grids of 5 nautical miles, 5,000 feet, and 1,000 feet, depending on the resolution required.

Underwater depth data and land heights for the model grid systems were obtained from NOAA nautical charts and USGS topographic maps (References 38, 55-58).

For areas subject to flooding directly from Lake Okeechobee (inside Herbert Hoover Dike), the FIA standard coastal surge model was used.

The stillwater elevations for the 10-, 50-, 100-, or 500-year floods for all flooding sources subject to tidal surge have been determined and are summarized in Tables 5 and 6, "Parameter Values for Surge Elevation," for Martin County and Lake Okeechobee, and in Table 7, "Summary of Stillwater Elevations." The analyses reported herein reflect the stillwater elevations due to tidal and wind setup effects.

This Countywide Restudy

The redelineation of the flood hazard zones from the October 2002 FIS includes adjusting the vertical datum from NGVD to NAVD datum. Vertical datum conversion (NGVD to NAVD) is -1.4 feet. Redelineation methods follow FEMA's Guidelines and Specifications for Mapping Partners (Reference 59).

For areas outside of Herbert Hoover Dike, additional analyses described in Section 3.2 established the one-percent-annual-chance flood elevations.

We have included Tables 5 and 6 from the October 2002 FIS report and have adjusted elevations in Table 7 from the October 2002 FIS report to reflect elevations in NAVD datum.

3.4 Coastal Hydraulic Analyses

Coastal hydraulic analyses, as defined herein, consider the flooding effects of wind generated waves on the stillwater levels described in Section 3.3 (coastal hydrologic analyses). Hydraulic analyses, considering storm characteristics and the shoreline and bathymetric characteristics of the flooding sources studied, were carried out from earlier studies to provide estimates of the elevations of the floods of the selected recurrence intervals along each of the shorelines. Users of the FIRM should also be aware that coastal flood elevations are provided in the Summary of Stillwater Elevations table in this report. If the elevation on the FIRM is higher than the elevation shown in this table, a wave height, wave runup and/or wave setup component likely exists, in which case, the higher elevation should be used for construction and/or floodplain management purposes.

Data for the 1983 FIS Supplement-Wave Height Analysis were used for the 2002 and this county-wide study. This data provided flood hazard mapping for all open coast and interior bays and estuaries. Unfortunately, the interior data for WHAFIS models and transect locations were unavailable. Therefore, this study only presents the open coast transects developed in the 2002 study.

October 4, 2002 FIS Countywide Study

As part of the October 2002 FIS study, stillwater surge elevations were revised to include near shore wave setup. Based on the revised stillwater elevations, the coastal flood hazard analyses included wave hindcasting, beach erosion, wave runup, wave height, and flood hazard mapping along the entire Martin County coastline. These tasks are described below.

The methodology for analyzing the effects of wave heights associated with coastal storm surge flooding is described in the National Academy of Sciences report (Reference 60). This method is based on the following major concepts. First, depth-limited waves in shallow water reach a maximum breaking height that is equal to 0.78 times the stillwater depth. The wave crest is 70 percent of the total wave height above the stillwater level. The second major concept is that wave height may be diminished by dissipation of energy due to the presence of obstructions such as sand dunes, dikes and seawalls, buildings, and vegetation. The amount of energy dissipation is a function of the physical characteristics of the obstruction and is determined by procedures prescribed in Reference 1. The third major concept is that wave height can be regenerated in open fetch areas due to the transfer of wind energy to the water. This added energy is related to fetch length and depth.

As of 1989, FEMA defines a "coastal high hazard area" as an area of special flood hazards extending from offshore to the inland limit of a primary frontal dune along an open coast and any other area subject to high velocity wave action (i.e., wave heights greater than or equal to 3 feet) from storms or seismic sources. The "primary frontal dune" is defined as a continuous or nearly continuous mound or ridge of sand with relatively steep seaward and landward slopes immediately landward and adjacent to the beach and subject to erosion and overtopping from high tides and waves during major coastal storms. The inland limit of the primary frontal dune occurs at the point where there is a distinct change from a relatively steep slope to a relatively mild slope.

Central Pressure Depression (mb)	Value (mb)	7.5	17.5	27.5	37.5		47.5	57.5	67.5	77.5	87.5	97.5	107.5	117.5
	Probability:													
	Existing	0.1891	0.1461	0.1147	0.1290		0.1268	0.1161	0.0773	0.0412	0.0200	0.0200	0.0100	0.0100
	Entering	0.1557	0.1208	0.1102	0.1438		0.1414	0.1294	0.0862	0.0459	0.0220	0.0220	0.0110	0.0110
	Parallel	0.1891	0.1461	0.1147	0.1290		0.1268	0.1161	0.0773	0.0412	0.0200	0.0200	0.0100	0.0100
Storm Radius	Value (n. mi.)		22						30					
	Probability:		0.65						0.35					
Forward Speed	Value (knots)		8			14			20					
	Probability:													
	Exiting		0.29			0.45			0.26					
	Entering		0.69			0.22			0.09					
	Parallel		0.59			0.35			0.06					
Crossing Angle			Entering							Exiting				
	Value (deg.)	-90		-45			0		45		90			
	Probability:	0.09		0.22			0.23		0.24		0.22			
Rate of Storm Occurrence:	4.10 x 10 storms1n.m. year "													

TABLE 5

FEDERAL EMERGENCY MANAGEMENT AGENCY

**MARTIN COUNTY, FL
AND INCORPORATED AREAS**

PARAMETER VALUES FOR SURGE ELEVATION

MARTIN COUNTY

Central Pressure	Value (Hg)	27.39	27.68	27.97	28.26	28.55	28.86	29.12	29.4	29.7
	Assigned Probability:									
	Exiting	0.0600	0.0400	0.0000	0.1200	0.1270	0.1290	0.1150	0.1160	0.1890
	Landfalling	0.0670	0.6480	0.0060	0.1290	0.1410	0.1440	0.1100	0.1210	0.1560
Storm Radius	Value (n. mi.)				24					
	Assigned Probability:				1.0					
Forward Speed	Value (knots)		7			10			19	
	Assigned Probability:									
	Exiting		0.2230			0.4170			0.3550	
	Landfalling		0.6440			0.3080			0.0481	
Direction	Value (deg.)	-90		-45		0		45		90
	Assigned Probability	0.109		0.327		0.096		0.247		0.222
Spatial Occurrence Rate		3.23×10^{-3}				Crossing the coastline				
Storms/nm. Yr.		1.34×10^{-3}				Parallel to the coastline				

TABLE 6

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARTIN COUNTY, FL
AND INCORPORATED AREAS

PARAMETER VALUES FOR SURGE ELEVATION

LAKE OKEECHOBEE

Table 7 – Summary of Stillwater Elevations

FLOODING SOURCE AND LOCATION	ELEVATION (feet NAVD*)			
	10-Percent-Annual-Chance	2-Percent-Annual-Chance	1-Percent-Annual-Chance	0.2-Percent-Annual-Chance
ATLANTIC OCEAN				
Open coast, including Intracoastal Waterway from Great Pocket to Bridge Road	3.0	4.8	7.2	7.4
St. Lucie Inlet and Great Pocket	2.8	4.7	5.8	7.7
South Jupiter Narrows (north of Bridge Road)	3.0	4.8	5.6	7.4
Hobe Sound (south of Bridge Road)	2.2-2.5	**	4.8-5.1	**
Jupiter Sound	2.1-2.2	**	4.5-4.8	**
Northwest Fork Loxahatchee River	2.0-3.3	4.0-4.2	4.6	6.1
North Fork Loxahatchee River	2.1	4.0	4.5	6.0
INDIAN RIVER				
North of Jensen Beach Bridge, and east side, from Jensen Beach Bridge to south of Baker Point	1.9	4.9	6.0	8.0
East side, from south of Baker Point to St. Lucie Inlet	2.8	4.7	5.9	7.7
West side, from Jensen Beach Bridge to Sewall's Point	2.7	5.5	6.6	8.7
Entire shoreline within Sewall's Point	2.9	4.9	6.2	8.2
ST. LUCIE RIVER				
Entire shoreline within Sewall's Point	2.9	4.9	6.2	8.2
Mouth to Ocean Boulevard, including Manatee Pocket	3.1	4.9	6.1	8.2
Ocean Boulevard to U.S. Route 1	3.0	4.5	6.0	8.2
North and South Forks St. Lucie	3.0	4.5	6.0	8.2
LAKE OKEECHOBEE				
Okeechobee County limits to north of Chancey Bay	20.0	22.4	23.3	24.6
Chancey Bay Area	19.6	21.9	22.7	23.9
Confluence of St. Lucie Canal	19.3	21.3	22.1	23.3
Confluence of St. Lucie Canal to Palm Beach County limits	19.2	21.3	21.9	23.3

*North American Vertical Datum of 1988
**Data not available

For the City of Stuart, the October 2002 FIS includes a technical wave height analysis as specified in FEMA's "Guidelines and Specifications for Wave Elevation Determination and V Zone Mapping" (Reference 61). The October 2002 FIS updates the 1980 and 1996 FIS on the basis of FEMA's updated determinations of "coastal high hazard area" and "primary frontal dune," field investigation, and development of topography and aerial photography.

The coastal flooding analyses require transects defining the physical features of the offshore bathymetry and floodable onshore topography representative of the Martin County coastline. Thus, 15 representative transects (generally about one mile apart) were selected to represent spatial changes in topography, development, vegetation, and other physical characteristics that affect erosion, wave height, and wave runup. Transect locations, illustrated in Figure 2, "Transect Location Map," were selected based on field inspection and aerial photographs of the county's coastal region (References 21 and 62). Transects, generally perpendicular to the shoreline, terminated on the barrier island at the point where the surge elevation intersected the eroded profile. Coastal flood hazard analyses were not revised for interior shorelines because conditions have not significantly changed in these areas since the 2002 FIS was performed. Three transects were extended to the mainland to verify this assumption. Transects were obtained from field surveys of beach and offshore profiles, supplemented with 1:1,200 scale aerial photographs with contour intervals of 2 feet and the 1:24,000 scale USGS topographic maps with contour intervals of 5 feet (References 62 and 63). Surveys were positioned at and tied into Florida Department of Environmental Protection (FDEP) reference monuments.

Each transect was taken perpendicular to the shoreline and extended inland to a point where wave action ceased. Along each transect, wave heights and elevations were computed considering the combined effects of changes in ground elevation, vegetation, and physical features. The stillwater elevations for the 1-percent-annual-chance flood were used as the starting elevations for these computations. Wave heights were calculated to the nearest 0.1 foot, and wave elevations were determined at whole foot increments along the transects. The location of the 3-foot breaking wave for determining the terminus of the V Zone (area with velocity wave action) was also computed at each transect.

Wave heights were computed along transects (cross-section lines) along the coastal areas as shown in Figure 2 “Transect Location Map” and Figure 3 “Transect Location Map for Lake Okeechobee”. They were located in accordance with the Users Manual for Wave Height Analysis (Reference 64). The transects were located with consideration given to the physical and cultural characteristics of the land so that they would closely represent conditions in their locality. Transects were spaced close together in areas of complex topography and dense development. In areas having more uniform characteristics, they were spaced at larger intervals. It was also necessary to locate transects in areas where unique flooding existed and in areas where computed wave heights varied significantly between adjacent transects. Figure 4, "Transect Schematic," represents a sample transect, which illustrates the relationship between the stillwater elevation, the wave crest elevation, the ground elevation profile, and the location of the A/V zone boundary.

After analyzing wave heights along each transect, wave elevations were interpolated between transects. Various source data were used in the interpolation, including topographic maps (Reference 38), nautical charts (References 56-58), and aerial photographs (Reference 21). Controlling features affecting the elevations were identified and considered in relation to their positions at a particular transect and their variation between transects.

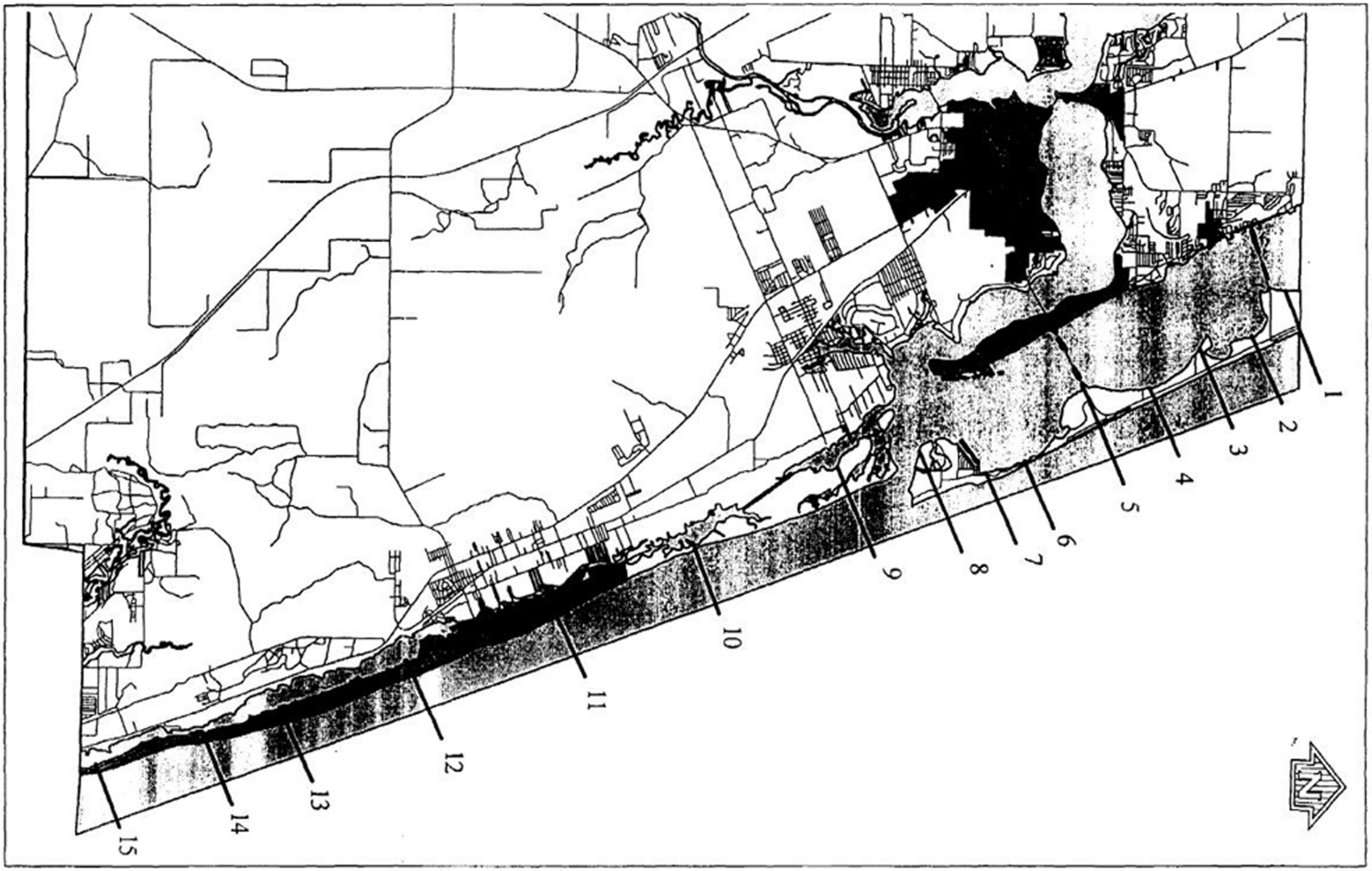

FIGURE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARTIN COUNTY, FL

APPROXIMATE SCALE

1 0 1 2 3 4 Miles

TRANSECT LOCATION MAP

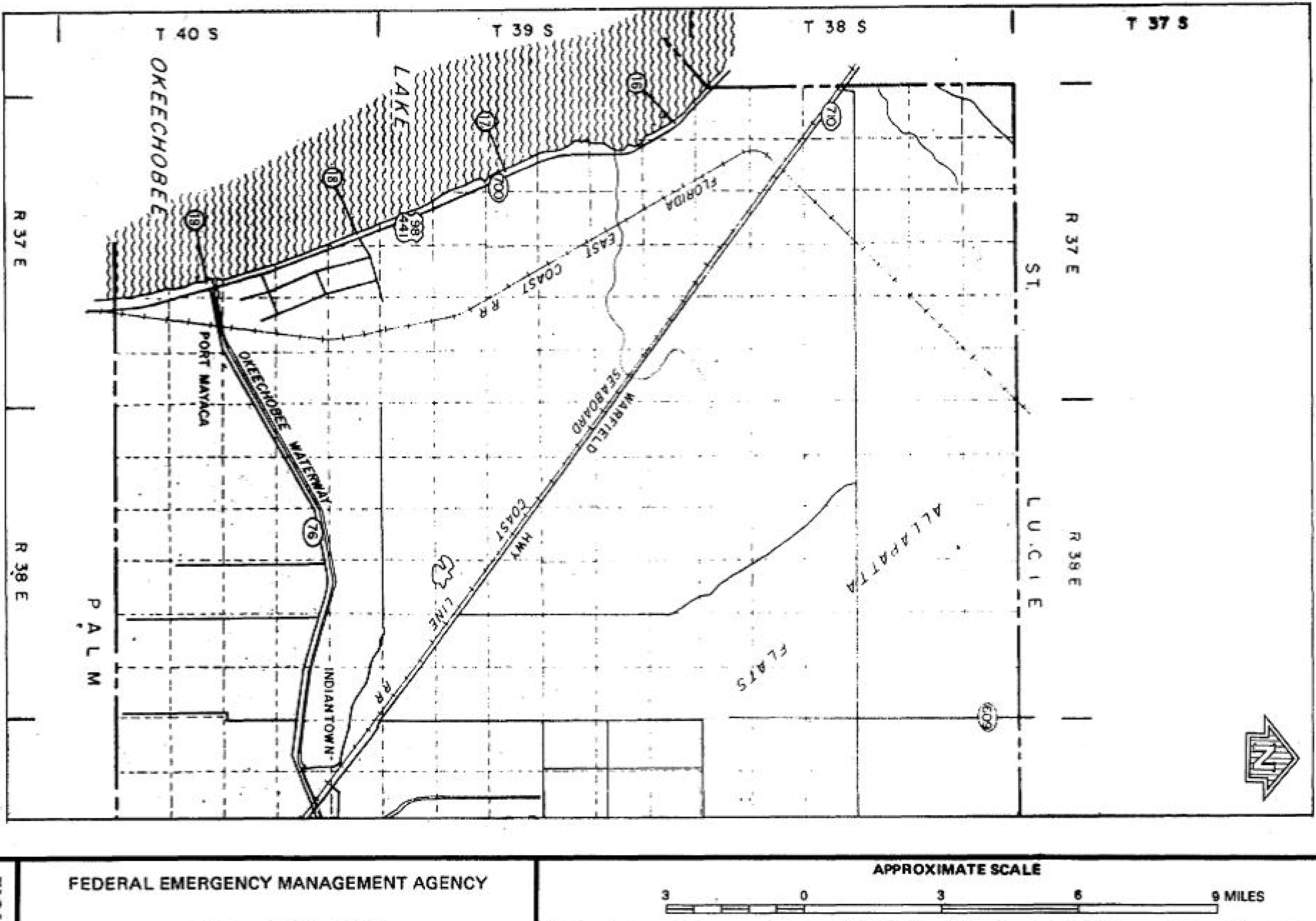

FIGURE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARTIN COUNTY, FL

TRANSECT LOCATION MAP (LAKE OKEECHOBEE)

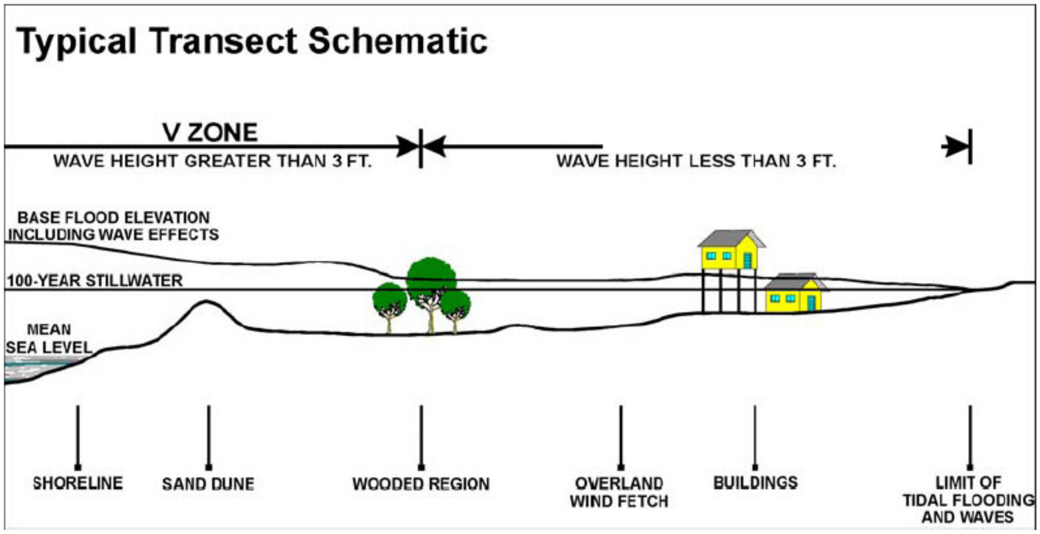

Figure 4 – Transect Schematic

Beach erosion was computed along each transect to determine the vertical and horizontal limits of the eroded escarpment corresponding to the 100-year flood event using the still water elevations. As detailed in FEMA's Guidelines and Specifications for Wave Elevation Determination and V Zone Mapping, transects with frontal dune reservoirs exceeding 540 square feet are considered to experience dune retreat while those with reservoirs 20 less than 540 square feet are considered to experience dune removal (References 61 and 65). Limited shore protection structures were identified within the study area; however, they were excluded from this study because appropriate design information was unavailable.

Based on the eroded profiles and the stillwater elevations, the wave envelope was computed for each transect. The wave envelope represents the maximum vertical and landward limit of wave activity and includes the wave crest and wave runup/wave setup elevations. The wave model WHAFIS provided the maximum expected wave crest elevation along each transect (Reference 65). This methodology accounted for fetch length, submerged bathymetry, and type and extent of land cover along each transect. Density, types and physical dimension of rigid and flexible vegetation, buildings, and other structures (e.g., height, stem diameters, horizontal spacing, etc.) were considered based on aerial photographs and field inspection.

FEMA's RUNUP model, based on wave runup/wave setup methodologies, then provided the maximum vertical limit of wave activity at the landward terminus of each transect (Reference 65). Representative deep water wave height and period combinations accompanying 100-year flooding events were obtained from available USACE Wave Information Studies (WIS) wave hindcast data. The hindcast wave climate for the nearest location was examined statistically in terms of extreme value theory to determine representative wave height-period combinations. The runup model was applied with wave heights ranging from the significant wave height to the wave height with an exceedance probability of 95% and corresponding wave periods to estimate maximum runup along each eroded transect.

Table 8 "Transect Descriptions," includes a description of each transect location, 100-year stillwater elevation, and maximum 100-year wave crest elevation for Transects 1 to 15 along the Atlantic Ocean (included in this countywide study). Information for the remaining transects was taken directly from the 1980 and 1996 FIS for Martin County (Reference 1).

Table 9 "Transect Data," includes the flooding source, 10-, 50-, 100-, and 500-year stillwater elevations, zone designation, and base flood elevation. Data for Transects 1 to 15 from the countywide study and data from the previous FISs are provided in Table 9.

This Countywide Restudy

The redelineation of the flood hazard zones from the October 2002 FIS includes adjusting the vertical datum from NGVD to NAVD datum.

This countywide analysis includes a datum adjustment to the 10-, 50-, 100-, and 500-year stillwater elevations. The October 2002 FIS values reported in NGVD have now been updated to reflect elevation values in NAVD. The Transect location maps for Martin County's open coast and Lake Okeechobee are from the October 2002 FIS report. Table 8 from the October 2002 FIS report has been adjusted to reflect the description of each transect location, 100-year still water elevation in NAVD and maximum 100-year wave crest elevation in NAVD.

Table 8 – Transect Descriptions

		ELEVATION (feet NAVD)	
TRANSECT	LOCATION	ATLANTIC 1-PERCENT-ANNUAL CHANCE STILLWATER[1]	MAXIMUM 1-PERCENT-ANNUAL CHANCE WAVE CREST[2]
1	Hutchinson Island - from the Atlantic Ocean coastline westward to the Indian River near the St. Lucie County line	7.2	14.6
2	Hutchinson Island - from the Atlantic Ocean coastline westward to the Indian River south of the NE Causeway Boulevard	7.2	14.6
3	Hutchinson Island - from the Atlantic coastline westward to the Indian River north of NE Joes Point Road	7.2	14.6
4	Hutchinson Island - from the Atlantic Ocean coastline westward to the Indian River, north of NE Shore Village Terrace	7.2	14.6
5	Hutchinson Island - from the Atlantic Ocean coastline westward to the Indian River, at Ocean Boulevard	7.2	14.6
6	Hutchinson Island - from the Atlantic Ocean coastline westward to the Indian River, south of the House of Refuge	7.2	14.6

Table 8 – Transect Descriptions

TRANSECT	LOCATION	ELEVATION (feet NAVD) ATLANTIC 1-PERCENT-ANNUAL CHANCE STILLWATER[1]	ELEVATION (feet NAVD) MAXIMUM 1-PERCENT-ANNUAL CHANCE WAVE CREST[2]
7	Hutchinson Island - From the Atlantic Ocean coastline westward to the Indian River, North of SE South Marina Way	7.2	14.6
8	Hutchinson Island - from the Atlantic Ocean coastline westward to the Indian River, north of St. Lucie Inlet	7.2	14.6
9	Jupiter Island - from the Atlantic Ocean coastline westward to the Indian River, south of St. Lucie Inlet	7.2	14.6
10	Jupiter Island - from the Atlantic Ocean coastline westward to the Indian River, ending at SE Gomez Avenue	7.2	14.6
11	Jupiter Island - from the Atlantic Ocean coastline westward to the Indian River, north of SE Marlin Circle	7.2	14.6
12	Jupiter Island - from the Atlantic Ocean coastline westward to the Indian River, just north of SE Reed Place	7.2	14.6
13	Jupiter Island - from the Atlantic Ocean coastline westward to the Indian River, ending west of Intracoastal Waterway	7.2	14.6
14	Jupiter Island - from the Atlantic Ocean coastline westward to the Indian River, ending west of Intracoastal Waterway	7.2	14.6
15	Jupiter Island - from the Atlantic Ocean coastline westward to the Indian River, at SE Jupiter Inlet Way	7.2	14.6

[1] Includes wave setup of 1.6 feet
[2] Because of map scale limitations, the maximum wave elevation may not be shown on the FIRM

Table 9 – Transect Data

FLOODING SOURCE	10-PERCENT ANNUAL CHANCE	2-PERCENT ANNUAL CHANCE	1-PERCENT ANNUAL CHANCE	0.2-PERCENT ANNUAL CHANCE	ZONE	BASE FLOOD ELEVATION (feet NAVD)
	ELEVATION (feet NAVD)					
ATLANTIC OCEAN Transects 1-15	3.0	4.8	7.2[1]	7.4	VE	12-10
					AE	8-5
LAKE OKEECHOBEE						
Transect 1	20.0	22.4	23.3	24.6	VE	31-29
					AE	17
Transects 2 – 3	19.6	21.9	22.7	23.9	VE	29-31
					AE	17
Transect 4	19.3	21.3	22.1	23.3	VE	29-27
					AE	22

[1] Includes wave setup of 1.6 feet

3.5 Vertical Datum

All FIS reports and FIRMs are referenced to a specific vertical datum. The vertical datum provides a starting point against which flood, ground, and structure elevations can be referenced and compared. Until recently, the standard vertical datum in use for newly created or revised FIS reports and FIRMs was the National Geodetic Vertical Datum of 1929 (NGVD29). With the completion of the North American Vertical Datum of 1988 (NAVD88), many FIS reports and FIRMs are now prepared using NAVD as the referenced vertical datum.

Some of the data used in this revision were taken from the prior effective FIS reports and FIRM's and adjusted to NAVD. The datum conversion factor from NGVD to NAVD in Martin County is -1.4 feet.

Flood elevations shown in this FIS report and on the FIRM are referenced to the NAVD 88. Structure and ground elevations in the country must, therefore, be referenced to the same vertical datum. It is important to note that adjacent communities may be referenced to NGVD 29. This may result in differences in base flood elevations across the corporate limits between the communities.

For more information regarding conversion between the NGVD 29 and NAVD 88, see the FEMA publication entitled Converting the National Flood Insurance Program to the North American Vertical Datum of 1988, visit the National Geodetic Survey website at www.ngs.noaa.gov, or contact the National Geodetic Survey at the following address: NGS Information Services

NOAA, N/NGS12
National Geodetic Survey SSMC-3, #9202
1315 East-West Highway
Silver Spring, Maryland 20910-3282
(301)713-3242

Temporary vertical monuments are often established during the preparation of a flood hazard analysis for the purpose of establishing local vertical control. Although these monuments are not shown on the FIRM, they may be found in the Technical Support Data Notebook associated with the FIS report and FIRM for this community. Interested individuals may contact FEMA to access these data.

To obtain current elevation, description, and/or location information for benchmarks shown on this map, please contact the Information Services Branch of the NGS at (301)713-3242, or visit their website at www.ngs.noaa.gov.

4.0 FLOODPLAIN MANAGEMENT APPLICATIONS

The NFIP encourages State and local governments to adopt sound floodplain management programs. Therefore, each FIS provides 1-percent-annual-chance flood elevations and delineations of the 1- and 0.2-percent-annual-chance floodplain boundaries and 1-percent-annual-chance floodway to assist communities in developing floodplain management measures. This information is presented on the FIRM and in many components of the FIS report, including Flood Profiles, Floodway Data table and Summary of Stillwater Elevations Table. Users should reference the data presented in the FIS report as well as additional information that may be available at the local map repository before making flood elevation and/or floodplain boundary determinations.

4.1 Floodplain Boundaries

To provide a national standard without regional discrimination, the 1-percent-annual-chance (100-year) flood has been adopted by FEMA as the base flood for floodplain management purposes. The 0.2-percent-annual-chance (500-year) flood is employed to indicate additional areas of flood risk in the community. For each stream studied in detail, the 100- and 500-year floodplain boundaries have been delineated using the flood elevations determined at each cross section. Between cross sections, the boundaries were interpolated using points and breaklines at a scale of 1:3000 with a contour interval of 0.5 feet.

The 1- and 0.2-percent-annual-chance floodplain boundaries are shown on the FIRM (Exhibit 2). On this map, the 1-percent-annual-chance floodplain boundary corresponds to the boundary of the areas of special flood hazards (Zones A, AE, AO, VE); and the 0.2-percent-annual-chance floodplain boundary corresponds to the boundary of areas of moderate flood hazards. In cases where the 1- and 0.2-percent-annual-chance floodplain boundaries are close together, only the 1-percent-annual-chance floodplain boundary has been shown. Small areas within the floodplain boundaries may lie above the flood elevations but cannot be shown due to limitations of the map scale and/or lack of detailed topographic data.

For the streams studied by approximate methods, only the 1-percent-annual-chance floodplain boundary is shown on the FIRM (Exhibit 2).

4.2 Floodways

Encroachment on floodplains, such as structures and fill, reduces flood-carrying capacity, increases flood heights and velocities, and increases flood hazards in areas beyond the encroachment itself. One aspect of floodplain management involves balancing the economic gain from floodplain development against the resulting increase in flood hazard. For purposes of the NFIP, a floodway is used as a tool to assist local communities in this aspect of floodplain management. Under this concept, the area of the 1-percent-annual-chance floodplain is divided into a floodway and a floodway fringe. The floodway is the channel of a stream, plus any adjacent floodplain areas, that must be kept free of encroachment so that the 1-percent-annual-chance flood can be carried without substantial increases in flood heights. Minimum Federal standards limit such increases to 1.0 foot, provided that hazardous velocities are not produced. The floodways in this study are presented to local agencies as minimum standards that can be adopted directly or that can be used as a basis for additional floodway studies.

The floodways presented in this study were computed for Coral Gardens Canal and Roebuck Creek and Manatee Creek on the basis of equal-conveyance reduction from each side of the floodplain. For Coral Gardens Canal and Roebuck Creek, floodway widths were computed at cross-sections. Between cross-sections, the floodway boundaries were interpolated. For Manatee Creek, the ICPR model reports some hydraulic parameters at links, and some others at nodes. Base peak flows and base peak velocities are reported at links, whereas the base water surface elevations, surcharges and floodway widths are reported at nodes. Since the 1-percent-annual-chance flood is contained within the banks for almost the entire length of Manatee Creek, the floodway widths have been mapped at top of banks. Manatee Creek has two storm water treatment ponds along it main channel. Since these ponds contain the 1-percent-annual-chance flood within its banks, the floodway was mapped along the top of the banks. Since the 2007 LIDAR data does not reflect the topography of these ponds and hence top of the banks were mapped based on the 2012 aerials (Reference 66). The results of the floodway computations are tabulated for selected cross sections and nodes and provided in Table 10, “Floodway Data”. In cases where the floodway and 1-percent-annual-chance floodplain boundaries are either close together or collinear, only the floodway boundary has been shown on the FIRM. Portions of the floodway for Loxahatchee River extend beyond the county boundary.

Near the mouths of streams studied in detail, floodway computations are made without regard to flood elevations on the receiving water body. Therefore, “Without Floodway” elevations presented in Table 6 for certain downstream cross-sections are lower than regulatory flood elevations in that area, which must take into account the 1-percent-annual-chance flooding due to backwater from other sources.

Encroachment into areas subject to inundation by floodwaters having hazardous velocities aggravates the risk of flood damage and heightens potential flood hazards by further increasing velocities. A listing of stream velocities at selected cross-sections is provided in Table 10, “Floodway Data”. To reduce the risk of property damage in areas where the stream velocities are high, the community may wish to restrict development in areas outside the floodway.

The area between the floodway and the 1-percent-annual-chance floodplain boundaries is termed the floodway fringe. The floodway fringe encompasses the portion of the floodplain that could be completely obstructed without increasing the water-surface elevation of the 1-percent-annual-chance flood more than 1 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to floodplain development are shown in Figure 5, “Floodway Schematic”.

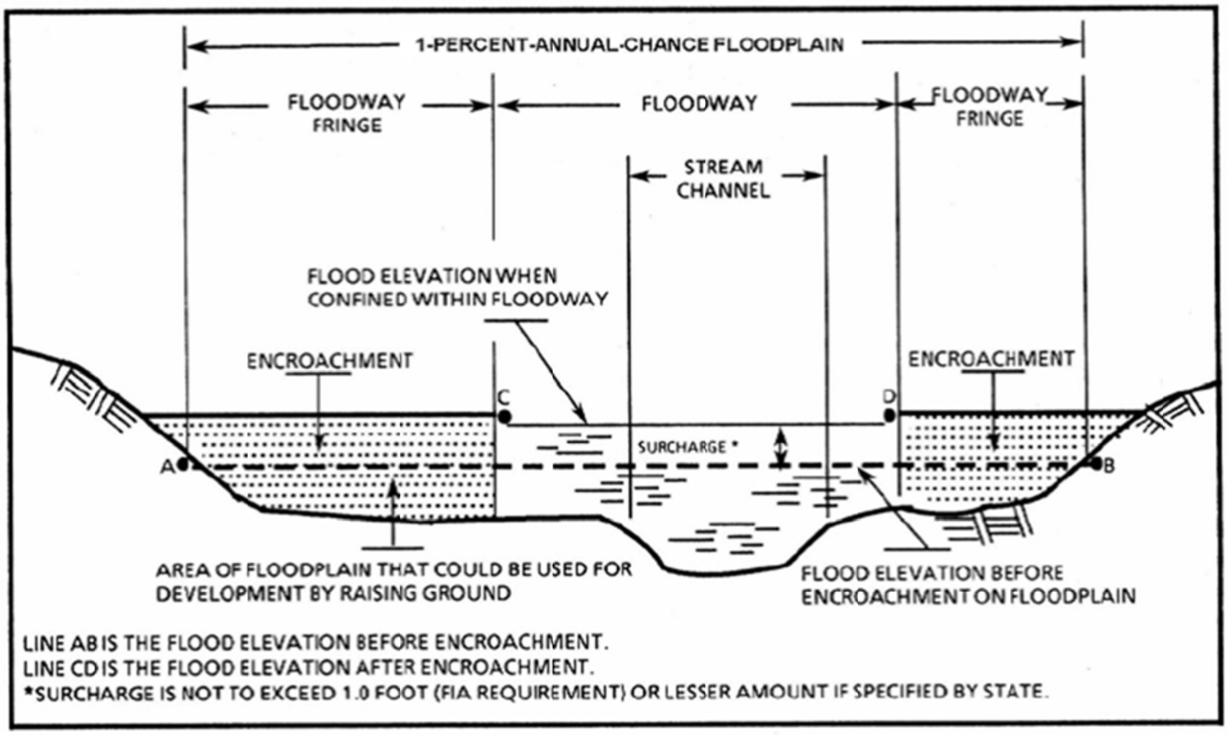

Figure 5 – Floodway Schematic

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE FLOOD WATER-SURFACE ELEVATION			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY (FEET NAVD)	WITHOUT FLOODWAY (FEET NAVD)	WITH FLOODWAY (FEET NAVD)	INCREASE (FEET)
Coral Gardens Canal								
A	824[1]	180	638	1.1	6.0*	2.2[3]	3.1	0.9
B	2,243[1]	70	163	1.7	7.2*	6.6[3]	7.2	0.6
C	3,386[1]	89	303	1.8	7.3*	6.7[3]	7.3	0.6
D	4,952[1]	50	172	3.1	9.7*	9.6[3]	9.7	0.1
E	5,845[1]	53	153	3.4	10.9*	10.8[3]	10.9	0.1
F	6,369[1]	57	287	1.8	13.4	13.4[3]	13.5	0.1
G	7,700[1]	54	430	1.2	15.6	15.6[3]	16.3	0.7
H	9,371[1]	60	431	1.2	16.2	16.2[3]	17.1	0.9
East Fork Creek								
A	155[2]	245	170	5.2	6.1*	0.3[4]	0.3	0.0
B	490[2]	42	329	2.7	6.3*	5.5[4]	5.5	0.0
C	510[2]	201	995	0.9	6.4*	5.6[4]	5.6	0.0
D	2,075[2]	86	223	4.0	6.4*	5.6[4]	5.6	0.0
E	2,709[2]	155	400	2.2	6.7*	6.1[4]	6.1	0.0
F	2,783[2]	26	183	4.9	7.3*	6.6[4]	6.6	0.0
G	4,061[2]	200	476	1.9	7.7*	7.3[4]	7.5	0.2
H	5,278[2]	51	181	4.4	8.3*	8.2[4]	8.2	0.0
I	5,326[2]	52	317	2.5	10.8	10.8[4]	10.8	0.0
J	5,405[2]	34	147	5.5	10.8	10.8[4]	10.8	0.0
K	6,288[2]	80	483	1.7	11.4	11.4[4]	11.4	0.0
L	7,171[2]	108	315	2.5	11.4	11.4[4]	11.5	0.1
M	8,131[2]	29	265	3.0	12.3	12.3[4]	12.4	0.1
N	9,571[2]	199	1,190	0.7	12.6	12.6[4]	12.7	0.1
O	11,211[2]	25	249	3.1	13.3	13.3[4]	13.4	0.1

[1] Feet above confluence with South Fork St. Lucie River
[2] Feet above confluence with Manatee Creek
[3] Elevation computed without consideration of backwater effects from South Fork St. Lucie River
[4] Elevation computed without consideration of backwater effects from Manatee Creek
* Includes coastal combined probability

TABLE 10

FEDERAL EMERGENCY MANAGEMENT AGENCY
MARTIN COUNTY, FL
AND INCORPORATED AREAS

FLOODWAY DATA

CORAL GARDENS CANAL - EAST FORK CREEK

FLOODING SOURCE			FLOODWAY			1-PERCENT-ANNUAL-CHANCE FLOOD WATER-SURFACE ELEVATION			
NODES[1]	LINKS	DISTANCE[2]	WIDTH (FEET)	BASE PEAK FLOW (CFS)	BASE PEAK VELOCITY (FPS)	REGULATORY (FEET NAVD)	WITHOUT FLOODWAY (FEET NAVD)	WITH FLOODWAY (FEET NAVD)	INCREASE (FEET)
010		2,824	73			6.1*	1.9	1.9	0.0
020		2,904	39			6.1*	2.2	2.2	0.0
	C-030			508	5.6				
030		3,774	46			6.1*	4.2	4.7	0.5
030A		3,873	45			6.1*	4.5	4.9	0.4
	C-030B			511	3.7				
030B		3,933	48			6.2*	5.2	6.2	1.0
	C-040			553	2.9				
040		4,048	315			7.4*	7.2	7.5	0.3
055		4,223	252			7.9*	7.7	8.0	0.3
	C-060			481	2.6				
060		4,745	83			8.0*	7.9	8.1	0.2
	C-060A			432	2.9				
060A		5,044	89			8.2*	8.1	8.3	0.2
080		7,824	87			10.2	10.2	10.2	0.0
	C-090B			335	1.5				
090B		8,174	39			10.2	10.2	10.3	0.0
	C-090C			339	2.1				
090C		8,701	39			10.4	10.4	10.4	0.0
120		9,460	73			11.4	11.4	11.6	0.2
	C-130			280	2.2				
130		9,558	34			11.5	11.5	11.7	0.2
	C-130A			236	1.6				
130A		9,781	55			11.6	11.6	11.7	0.1
	C-150			244	1.7				
150		10,245	39			11.7	11.7	11.8	0.1
	C-150A			210	2.2				
150A		11,246	15			12.0	12.0	12.1	0.1

[1] Only relevant nodes shown in FWDT. Additional nodes are shown on flood profile.

[2] Distance from confluence with Manatee Pocket

* Includes coastal combined probability

TABLE 10

FEDERAL EMERGENCY MANAGEMENT AGENCY
MARTIN COUNTY, FL
AND INCORPORATED AREAS

FLOODWAY DATA

MANATEE CREEK

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE FLOOD WATER-SURFACE ELEVATION			
CROSS SECTION	**DISTANCE**	**WIDTH (FEET)**	**SECTION AREA (SQUARE FEET)**	**MEAN VELOCITY (FEET PER SECOND)**	**REGULATORY (FEET NAVD)**	**WITHOUT FLOODWAY (FEET NAVD)**	**WITH FLOODWAY (FEET NAVD)**	**INCREASE (FEET)**
Loxahatchee River								
A	915[1]	1,733/1,450[5]	12,273	0.4	4.6	0.1[3]	0.1	0.0
B	22,850[1]	150	2,185	1.7	4.6	2.4[3]	2.6	0.2
C	25,650[1]	178	2,320	2.5	4.6	2.9[3]	3.2	0.3
D	28,650[1]	290	2,323	3.8	4.6	4.1[3]	4.8	0.7
E	30,250[1]	405	3,203	3.0	5.1	4.9	5.7	0.8
F	32,250[1]	246	2,192	3.9	5.7	5.7	6.6	0.9
G	34,250[1]	289	2,630	3.3	6.5	6.5	7.5	1.0
Roebuck Creek								
A	206[2]	87	323	2.7	6.0*	1.5[4]	1.6	0.1
B	1,230[2]	46	215	4.0	6.0*	2.3[4]	2.8	0.5
C	3,119[2]	260	699	1.1	6.0*	4.6[4]	5.3	0.7
D	3,866[2]	123	584	1.3	6.2*	5.8[4]	6.2	0.4
E	6,092[2]	45	265	1.8	7.2*	7.1[4]	7.6	0.5
F	8,895[2]	35	181	3.4	9.2*	9.2[4]	9.7	0.5
G	10,480[2]	55	292	1.9	10.9	10.9[4]	11.4	0.5
H	12,825[2]	68	465	1.0	13.0	13.0[4]	13.3	0.3
I	13,345[2]	61	334	1.0	13.4	13.4[4]	13.8	0.4
J	13,934[2]	50	385	0.6	15.2	15.2[4]	16.0	0.8
K	15,253[2]	114	732	0.3	15.3	15.3[4]	16.1	0.8
L	18,426[2]	46	174	1.1	16.0	16.0[4]	16.6	0.6
M	19,410[2]	55	127	0.9	16.4	16.4[4]	16.9	0.5

[1] Feet above county boundary
[2] Feet above confluence with St. Lucie Canal
[3] Elevation computed without consideration of backwater effects from Atlantic Ocean
[4] Elevation computed without consideration of backwater effects from St. Lucie Canal Okeechobee Waterway
[5] Width/width within county boundary

* Includes coastal combined probability

TABLE 10	FEDERAL EMERGENCY MANAGEMENT AGENCY **MARTIN COUNTY, FL** **AND INCORPORATED AREAS**	**FLOODWAY DATA** **LOXAHATCHEE RIVER - ROEBUCK CREEK**

FLOODING SOURCE		FLOODWAY			1-PERCENT-ANNUAL-CHANCE FLOOD WATER-SURFACE ELEVATION			
CROSS SECTION	**DISTANCE**	**WIDTH (FEET)**	**SECTION AREA (SQUARE FEET)**	**MEAN VELOCITY (FEET PER SECOND)**	**REGULATORY (FEET NAVD)**	**WITHOUT FLOODWAY (FEET NAVD)**	**WITH FLOODWAY (FEET NAVD)**	**INCREASE (FEET)**
Roebuck Creek (Continued)								
N	20,456[1]	24	76	1.4	17.2	17.2[2]	17.5	0.3
O	21,543[1]	91	105	0.3	17.6	17.6[2]	17.7	0.1
P	22,587[1]	72	100	0.3	17.7	17.7[2]	17.8	0.1
South Fork St. Lucie River								
A	15,016[1]	116	1,739	1.9	6.0	4.5[2]	5.4	0.9
B	17,453[1]	135	2,212	1.5	6.0	4.7[2]	5.6	0.9
C	18,901[1]	109	1,493	2.2	6.0	4.8[2]	5.7	0.9
D	20,225[1]	109	1,510	2.2	6.0	5.0[2]	5.9	0.9
E	23,029[1]	86	1,471	2.3	6.0	5.3[2]	6.3	1.0
F	25,723[1]	745	2,945	1.0	6.0	5.5[2]	6.5	1.0
G	28,542[1]	77	980	3.1	6.0	6.0[2]	7.0	1.0
H	30,713[1]	152	1,490	2.0	6.5	6.5	7.5	1.0
I	33,869[1]	380	2,131	1.4	7.2	7.2	8.2	1.0
J	37,326[1]	491	3,054	0.8	8.1	8.1	9.1	1.0
K	39,818[1]	402	2,914	0.8	8.5	8.5	9.5	1.0
L	41,641[1]	817	4,461	0.2	8.5	8.5	9.5	1.0
M	43,465[1]	237	1,726	0.4	8.6	8.6	9.6	1.0

[1] Feet above confluence with St. Lucie Canal Okeechobee Waterway
[2] Elevation computed without consideration of backwater effects from St. Lucie Canal Okeechobee Waterway

TABLE 10

FEDERAL EMERGENCY MANAGEMENT AGENCY
MARTIN COUNTY, FL
AND INCORPORATED AREAS

FLOODWAY DATA

ROEBUCK CREEK - SOUTH FORK ST. LUCIE RIVER

5.0 INSURANCE APPLICATIONS

For flood insurance rating purposes, flood insurance zone designations are assigned to a community based on the results of the engineering analyses. These zones are as follows:

Zone A

Zone A is the flood insurance risk zone that corresponds to the 1-percent-annual-chance floodplains that are determined in the FIS by approximate methods. Because detailed hydraulic analyses are not performed for such areas, no BFEs or base flood depths are shown within this zone.

Zone AE

Zone AE is the flood insurance risk zone that corresponds to the 1-percent-annual-chance floodplains that are determined in the FIS by detailed methods. In most instances, whole-foot BFEs derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone AH

Zone AH is the flood insurance risk zone that corresponds to the areas of 1-percent-annual-chance shallow flooding (usually areas of ponding) where average depths are between 1 and 3 feet. Whole-foot BFEs derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone VE

Zone VE is the flood insurance risk zone that corresponds to the 1-percent-annual-chance coastal floodplains that have additional hazards associated with storm waves. Whole-foot BFEs derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone X

Zone X is the flood insurance risk zone that corresponds to areas outside the 0.2-percent-annual-chance floodplain, areas within the 0.2-percent-annual-chance floodplain, areas of 1-percent-annual-chance flooding where average depths are less than 1 foot, areas of 1-percent-annual-chance flooding where the contributing drainage area is less than 1 square mile, and areas protected from the 1-percent-annual-chance flood by levees. No BFEs or base flood depths are shown within this zone.

6.0 FLOOD INSURANCE RATE MAP

The FIRM is designed for flood insurance and floodplain management applications.

For flood insurance applications, the map designates flood insurance risk zones as described in Section 5.0 and, in the 1-percent-annual-chance floodplains that were studied by detailed methods, shows selected whole-foot BFEs or average depths. Insurance agents use the zones and BFEs in conjunction with information on structures and their contents to assign premium rates for flood insurance policies.

For floodplain management applications, the map shows by tints, screens, and symbols, the 1- and 0.2-percent-annual-chance floodplains, floodways, and the locations of selected cross sections used in the hydraulic analyses and floodway computations.

The current FIRM presents flooding information for the entire geographic area of Martin County. This countywide FIRM also includes flood-hazard information that was historically presented separately on Floodway Maps (FBFMs), where applicable. Historical data relating to the maps prepared for each community, prior to the initial FIRM, are presented in Table 11, "Community Map History".

7.0 OTHER STUDIES

The Flood Insurance Study for the unincorporated areas of Okeechobee, Palm Beach and St. Lucie Counties is in agreement with this study (Reference 67-69).

Information pertaining to revised and unrevised flood hazards for each jurisdiction within Martin County has been compiled into this FIS. Therefore, this FIS report supersedes or is compatible with all previously printed FIS reports, FIRMs, and FBFMs for all jurisdictions within Martin County and should be considered authoritative for the purposes of the NFIP.

8.0 LOCATION OF DATA

Information concerning the pertinent data used in the preparation of this study can be obtained by contacting Federal Insurance and Mitigation Division, FEMA Region IV, Koger-Center – Rutgers Building, 3003 Chamblee Tucker Road, Atlanta, Georgia 30341.

COMMUNITY NAME	INITIAL IDENTIFICATION	FLOOD HAZARD BOUNDARY MAP REVISIONS DATES	FIRM EFFECTIVE DATE	FIRM REVISIONS DATE
Jupiter Island, Town of	May 24, 1974	None	February 2, 1977	October 1, 1983 January 5, 1984 June 16, 1992 October 4, 2002
Martin County (Unincorporated Areas)	July 29, 1977	None	June 15, 1981	October 1, 1983 January 5, 1984 June 16, 1992 September 29, 1996 June 30, 1999 October 4, 2002
Ocean Breeze Park, Town of	August 2, 1974	April 2, 1976	June 15, 1981	December 15, 1983 October 4, 2002
Sewall's Point, Town of	March 15, 1974	November 28, 1975	August 15, 1978	April 3, 1984 June 16, 1992 October 16, 1996 October 4, 2002
Stuart, City of	May 24, 1974	February 13, 1976 December 10, 1976	August 15, 1978	June 22, 1998 October 4, 2002

TABLE 11

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARTIN COUNTY, FL
AND INCORPORATED AREAS

COMMUNITY MAP HISTORY

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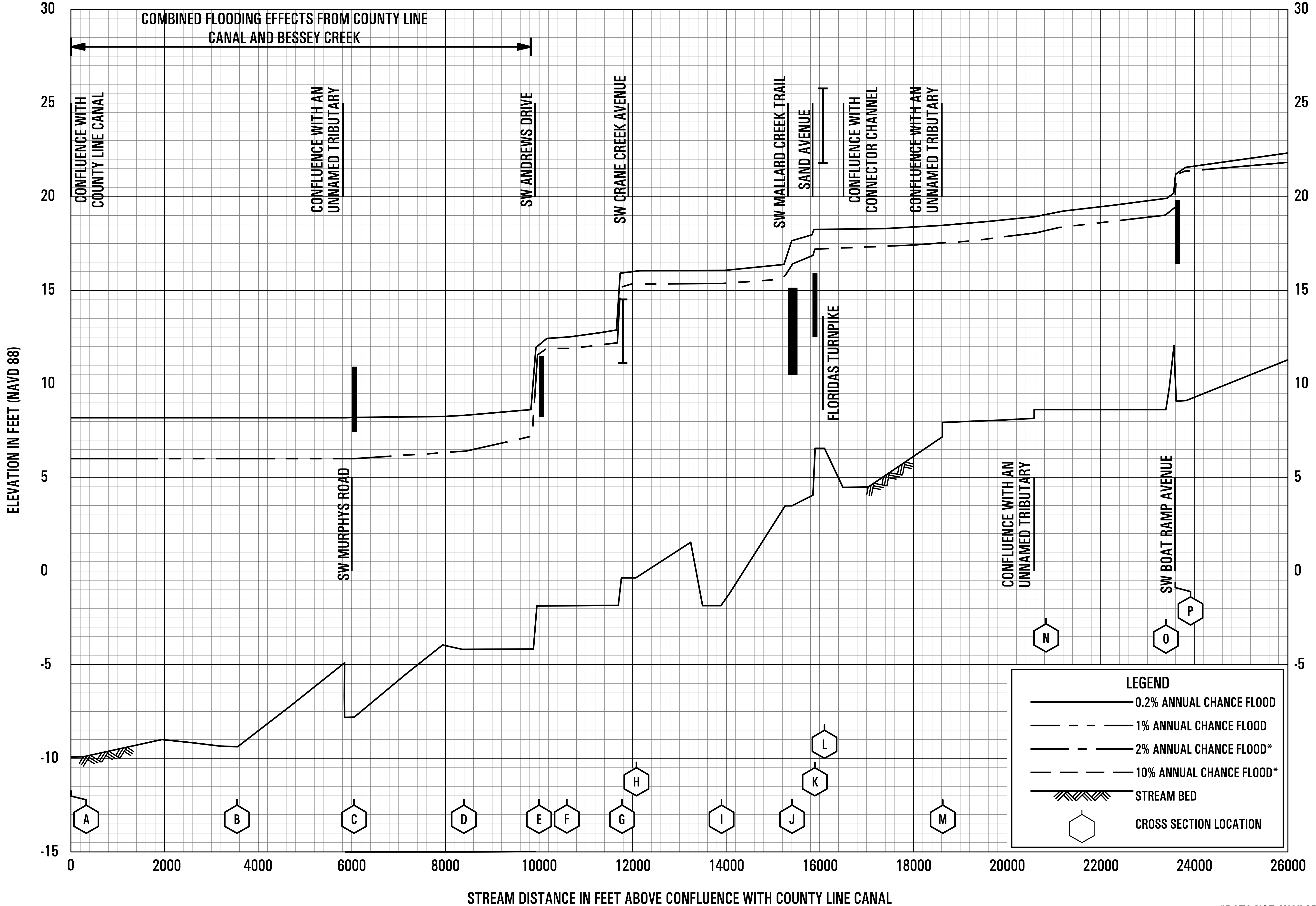

FLOOD PROFILES

BESSEY CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARTIN COUNTY, FL

AND INCORPORATED AREAS

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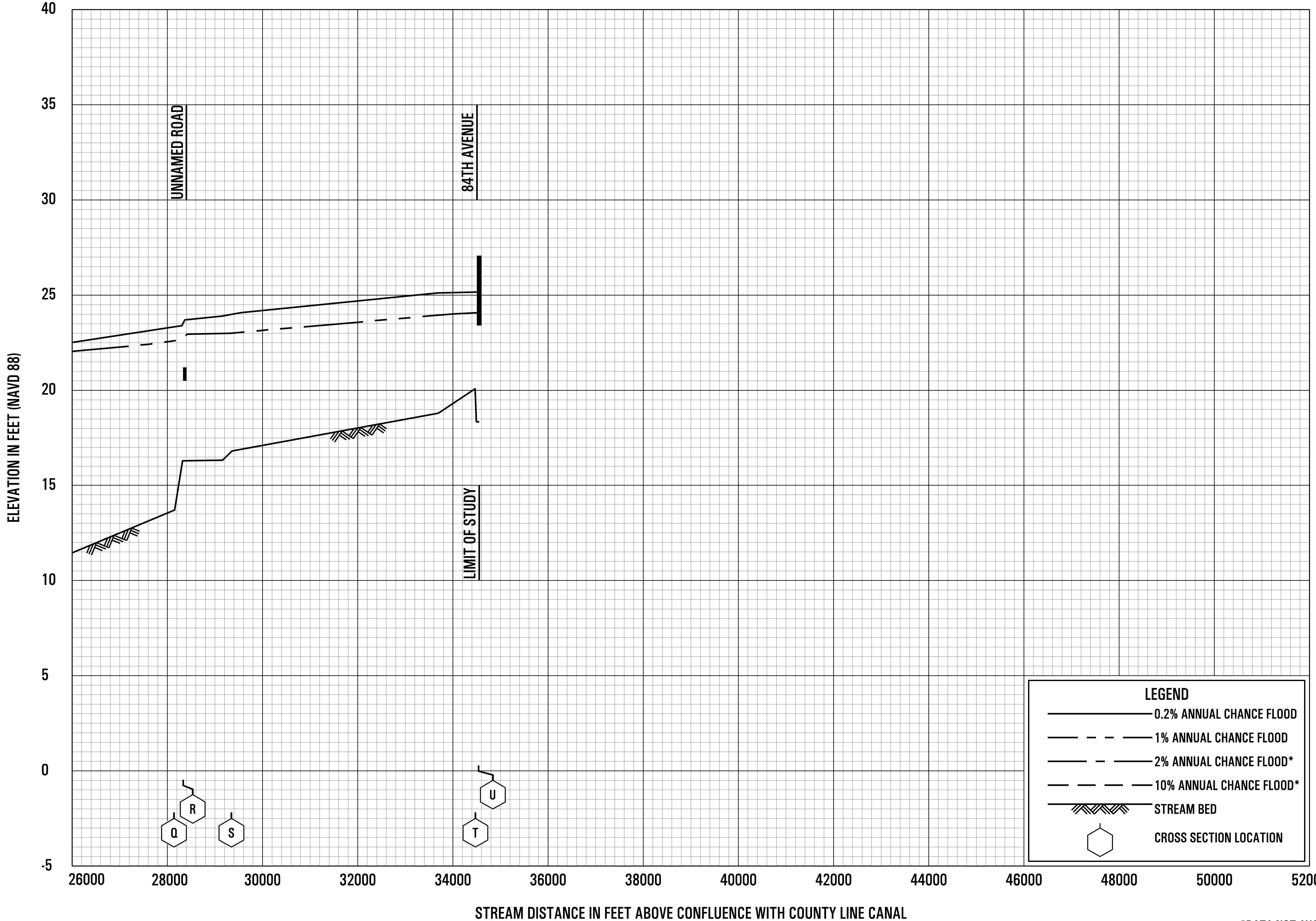


*DATA NOT AVAILABLE

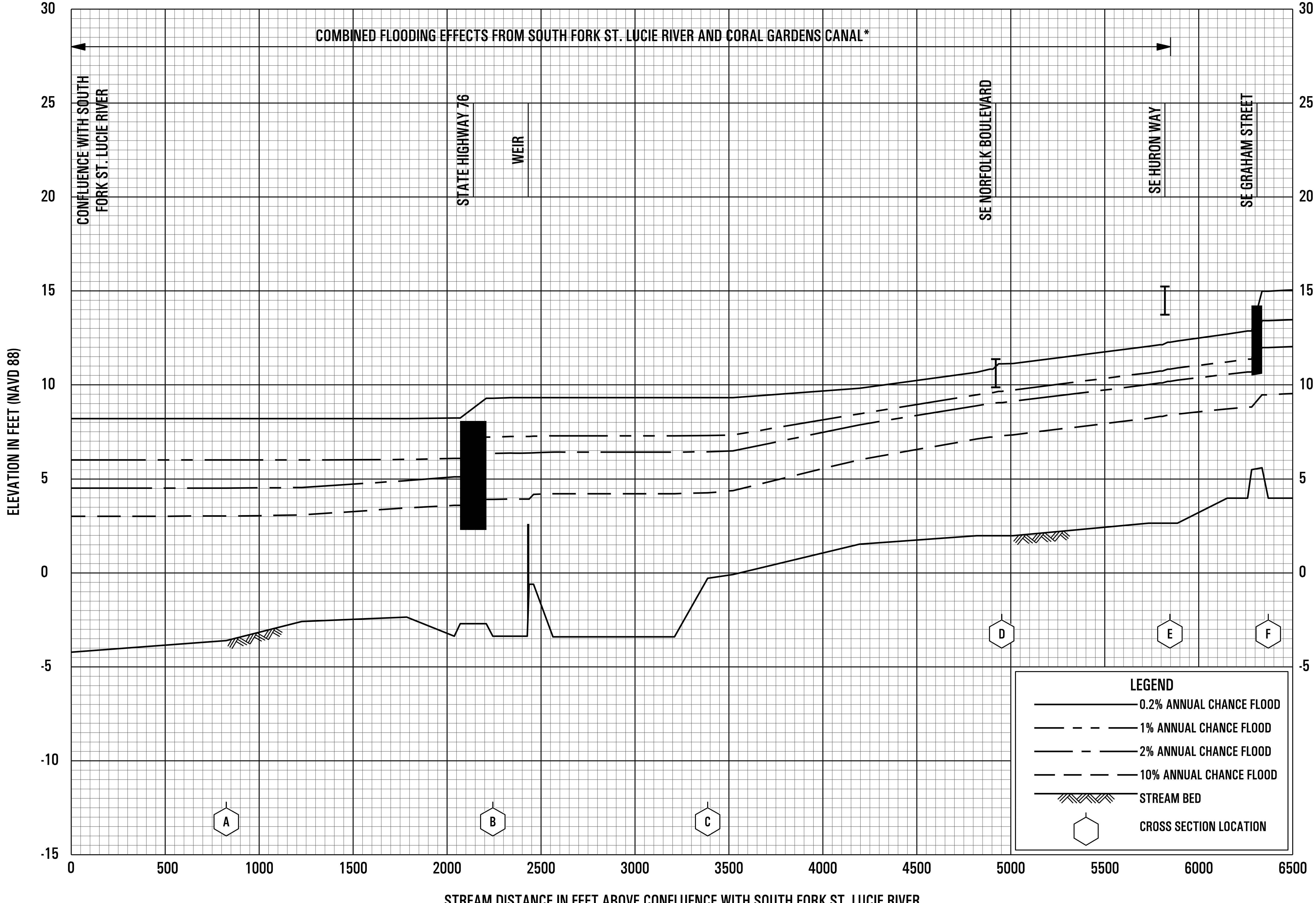
FLOOD PROFILES

BESSEY CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARTIN COUNTY, FL

AND INCORPORATED AREAS



*INCLUDES COASTAL COMBINED PROBABILITY

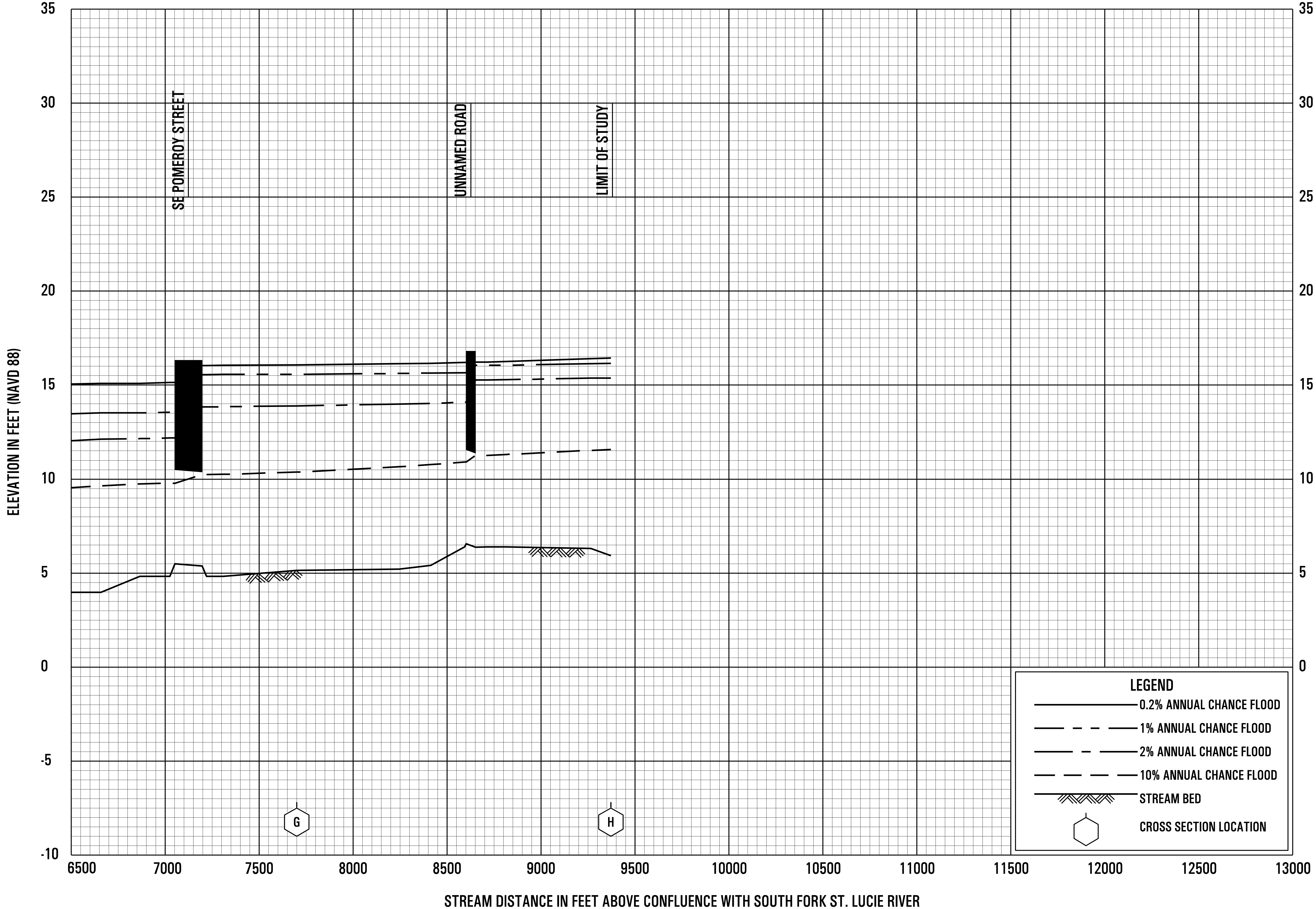
FLOOD PROFILES

CORAL GARDENS CANAL

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARTIN COUNTY, FL

AND INCORPORATED AREAS



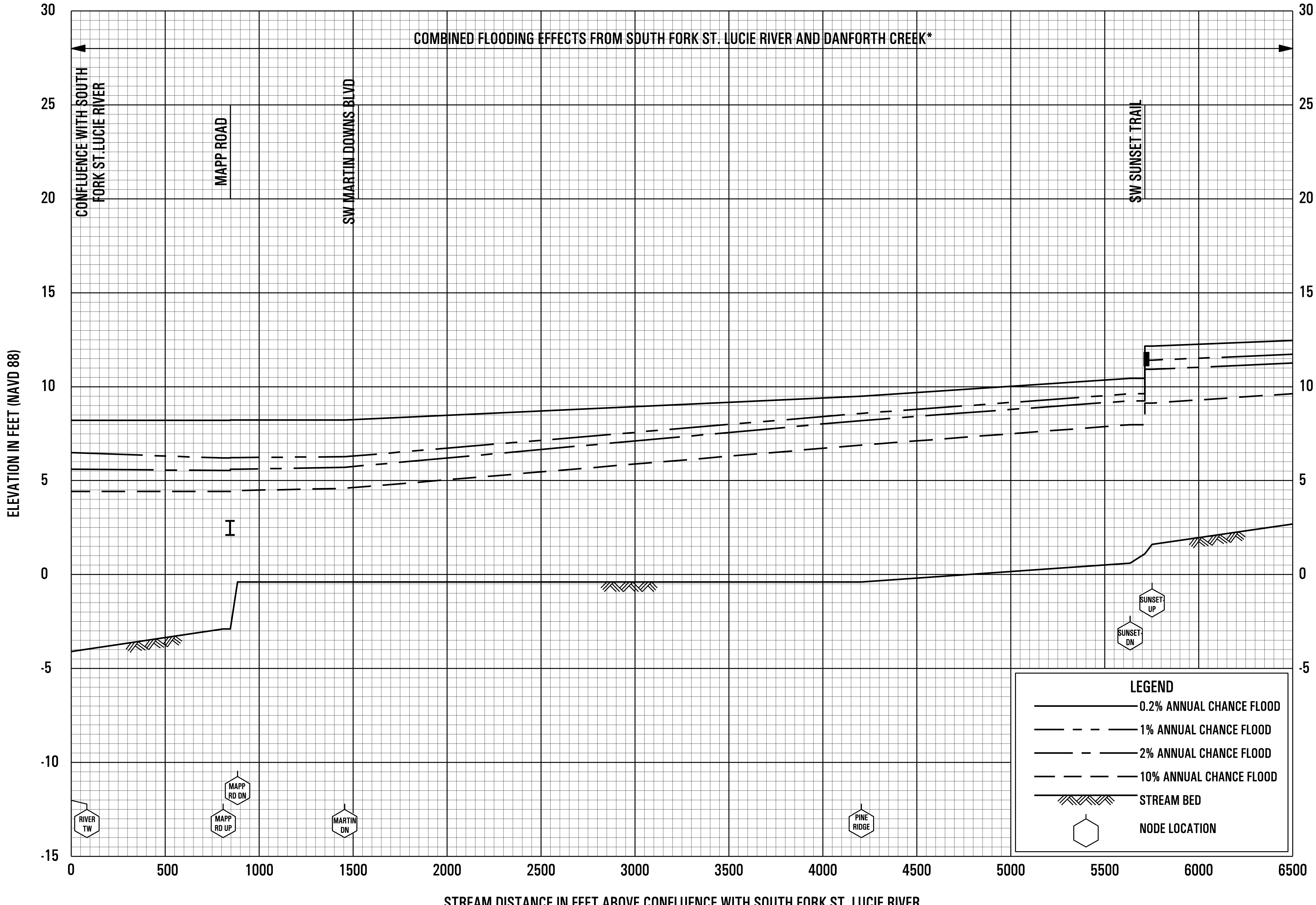
FLOOD PROFILES

CORAL GARDENS CANAL

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARTIN COUNTY, FL

AND INCORPORATED AREAS



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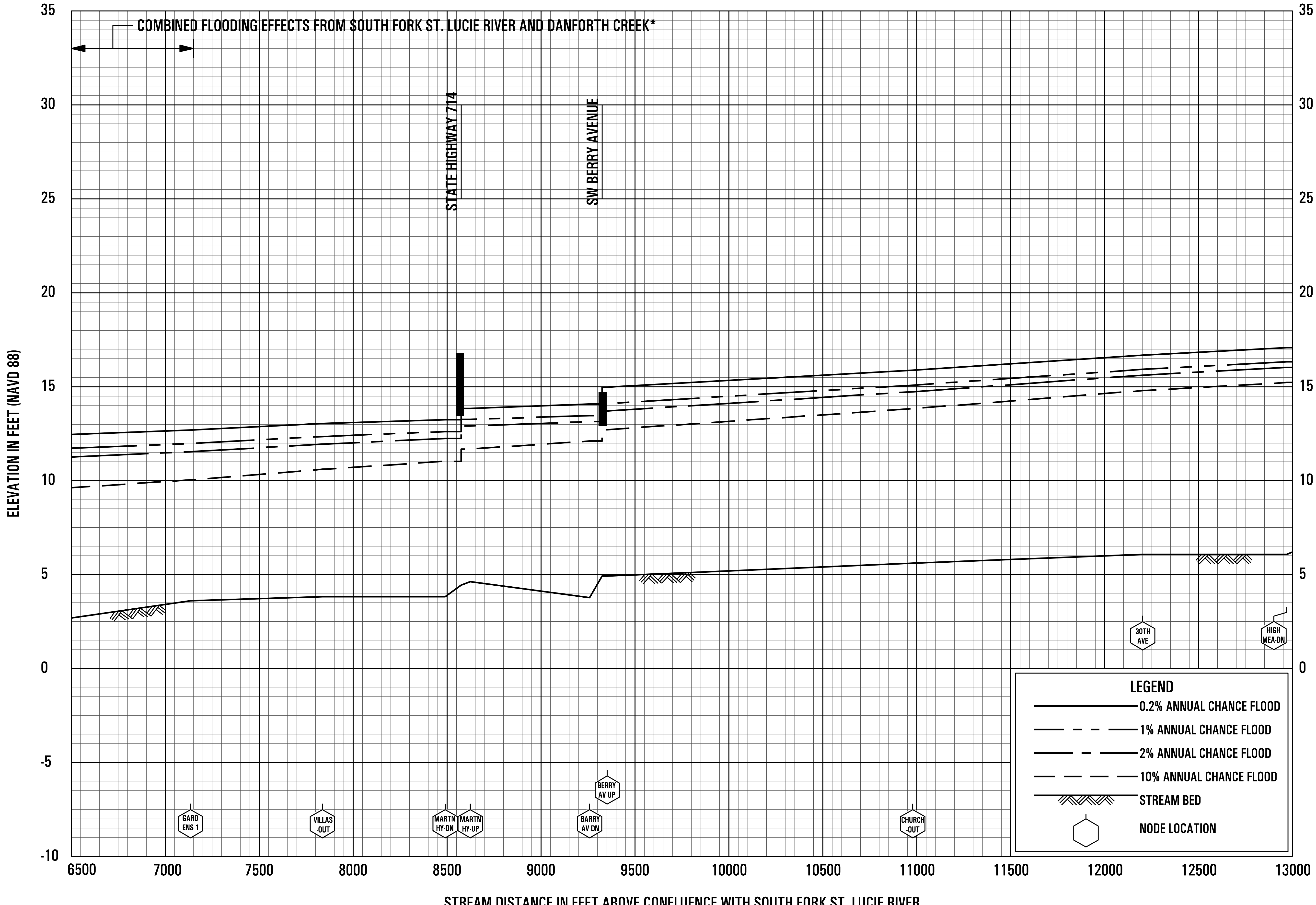
FLOOD PROFILES

DANFORTH CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARTIN COUNTY, FL

AND INCORPORATED AREAS



*INCLUDES COASTAL COMBINED PROBABILITY

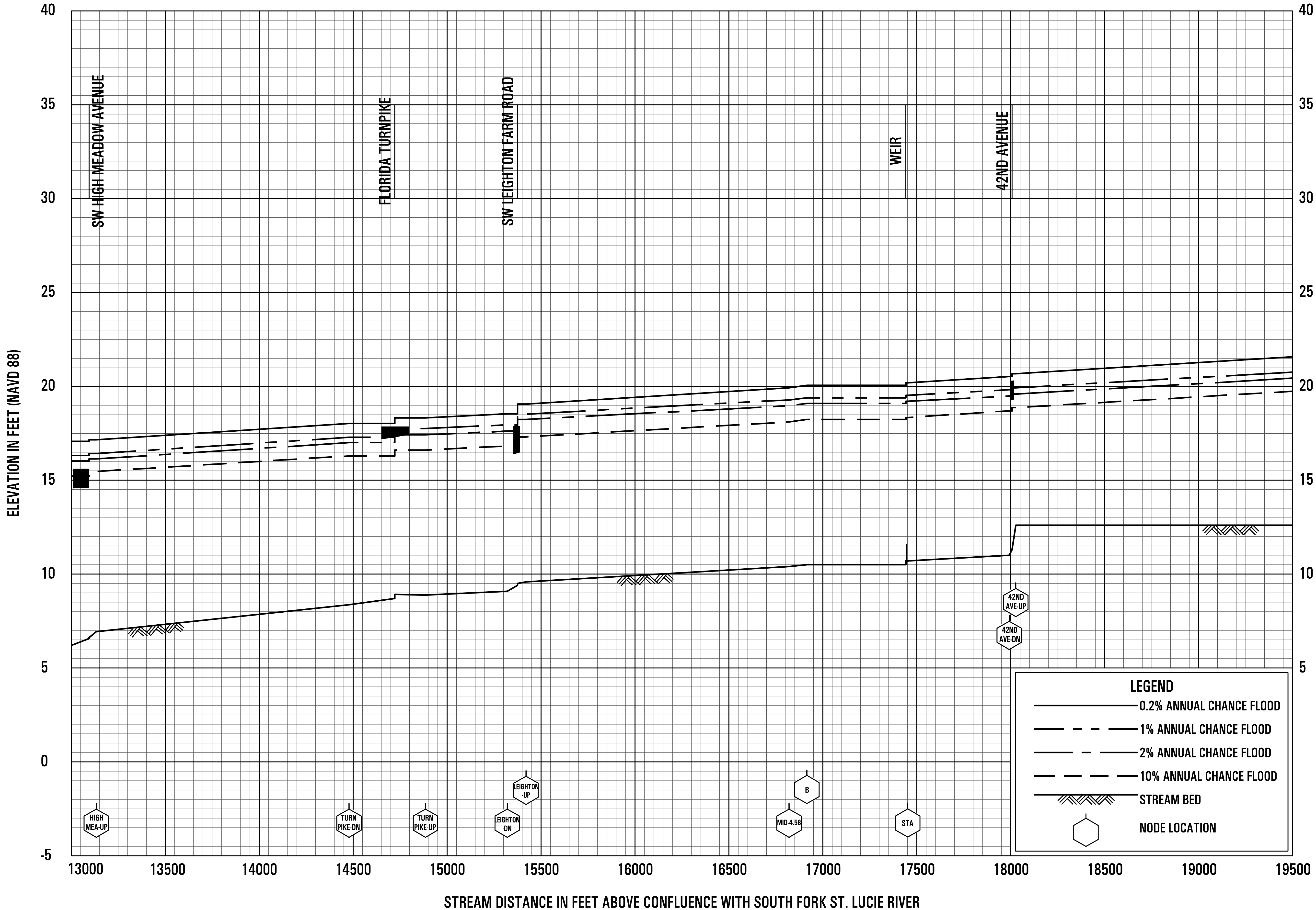
FLOOD PROFILES

DANFORTH CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARTIN COUNTY, FL

AND INCORPORATED AREAS



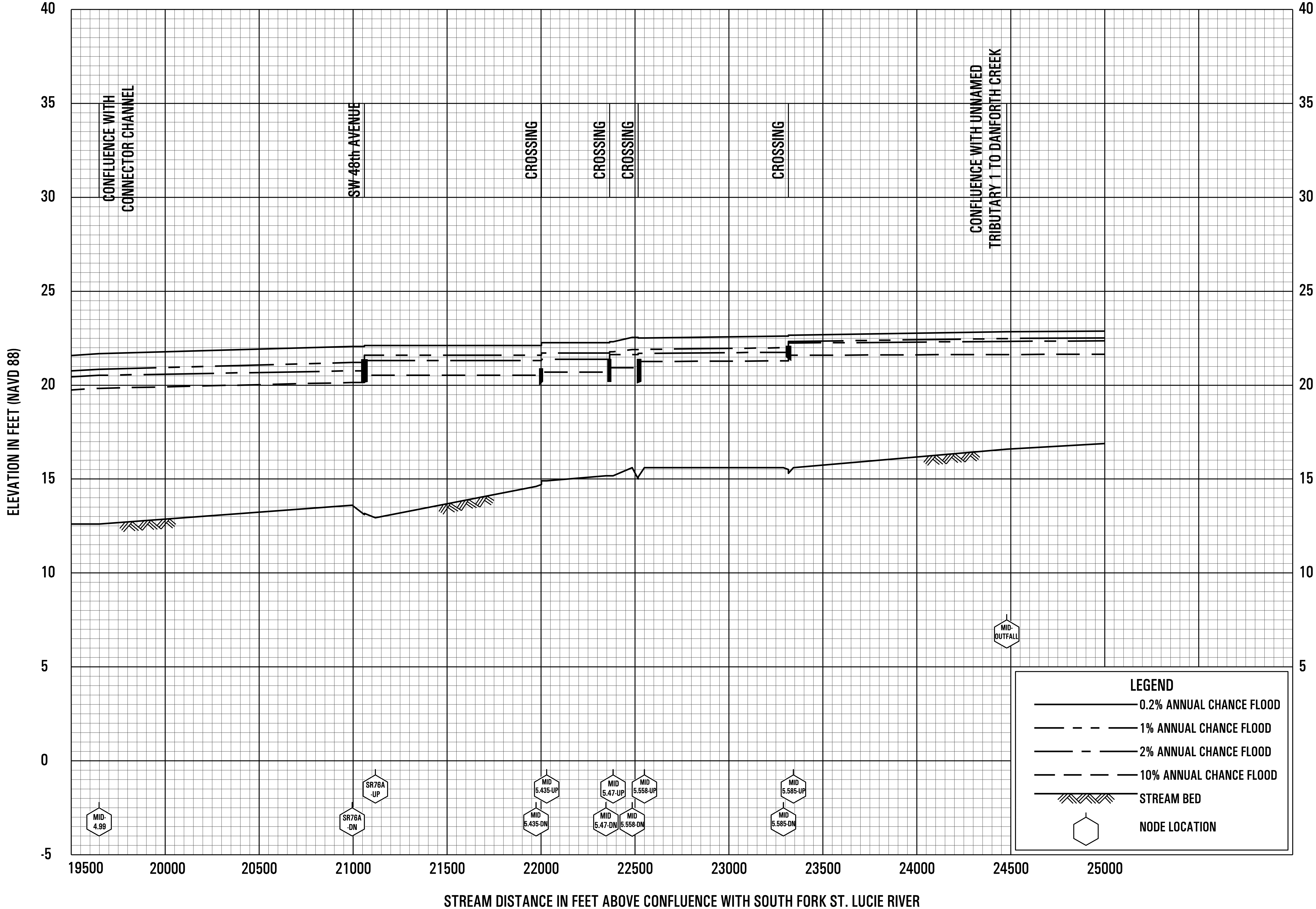
FLOOD PROFILES

DANFORTH CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARTIN COUNTY, FL

AND INCORPORATED AREAS



FLOOD PROFILES

DANFORTH CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARTIN COUNTY, FL

AND INCORPORATED AREAS

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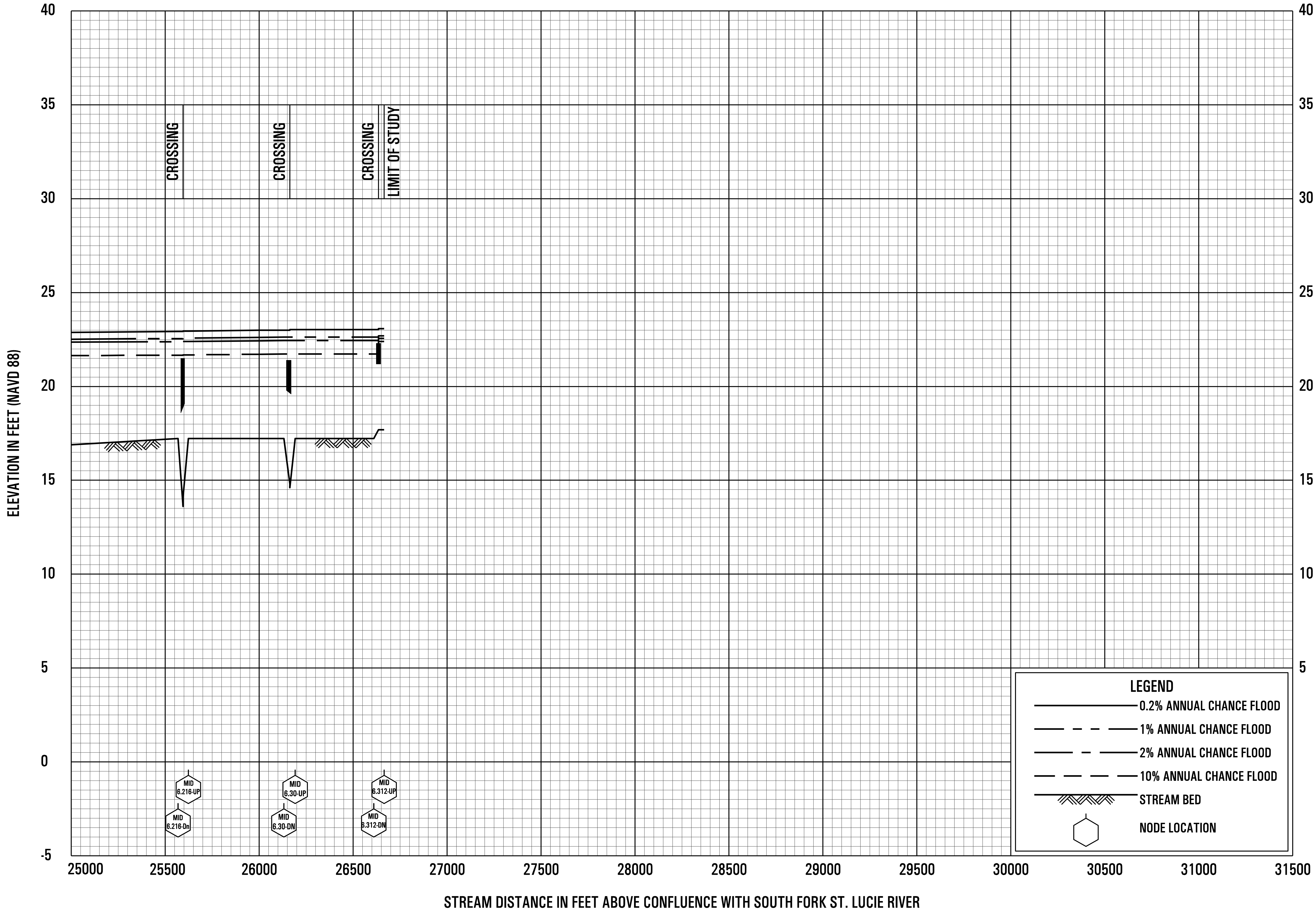

FLOOD PROFILES

DANFORTH CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARTIN COUNTY, FL

AND INCORPORATED AREAS

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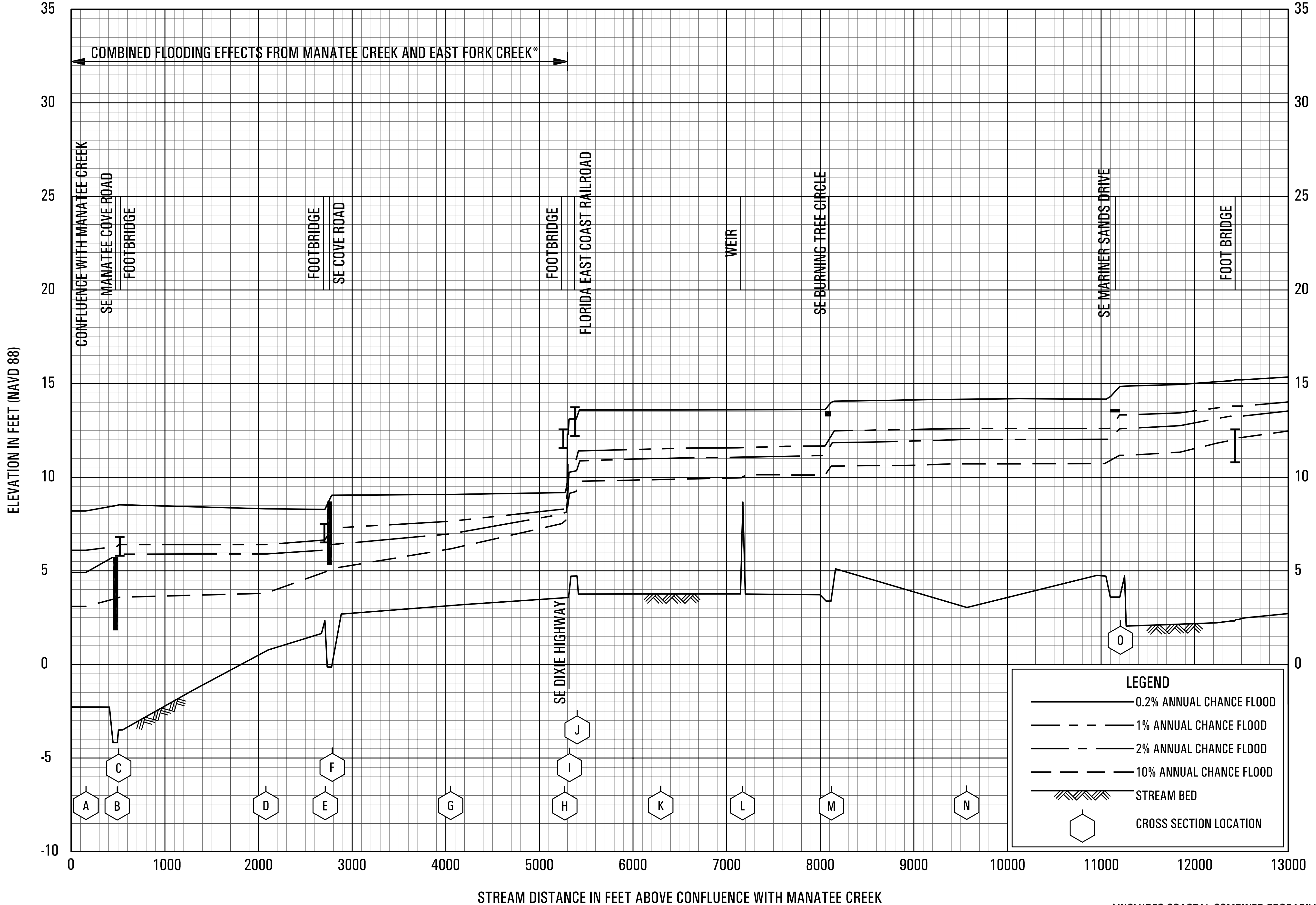


*INCLUDES COASTAL COMBINED PROBABILITY

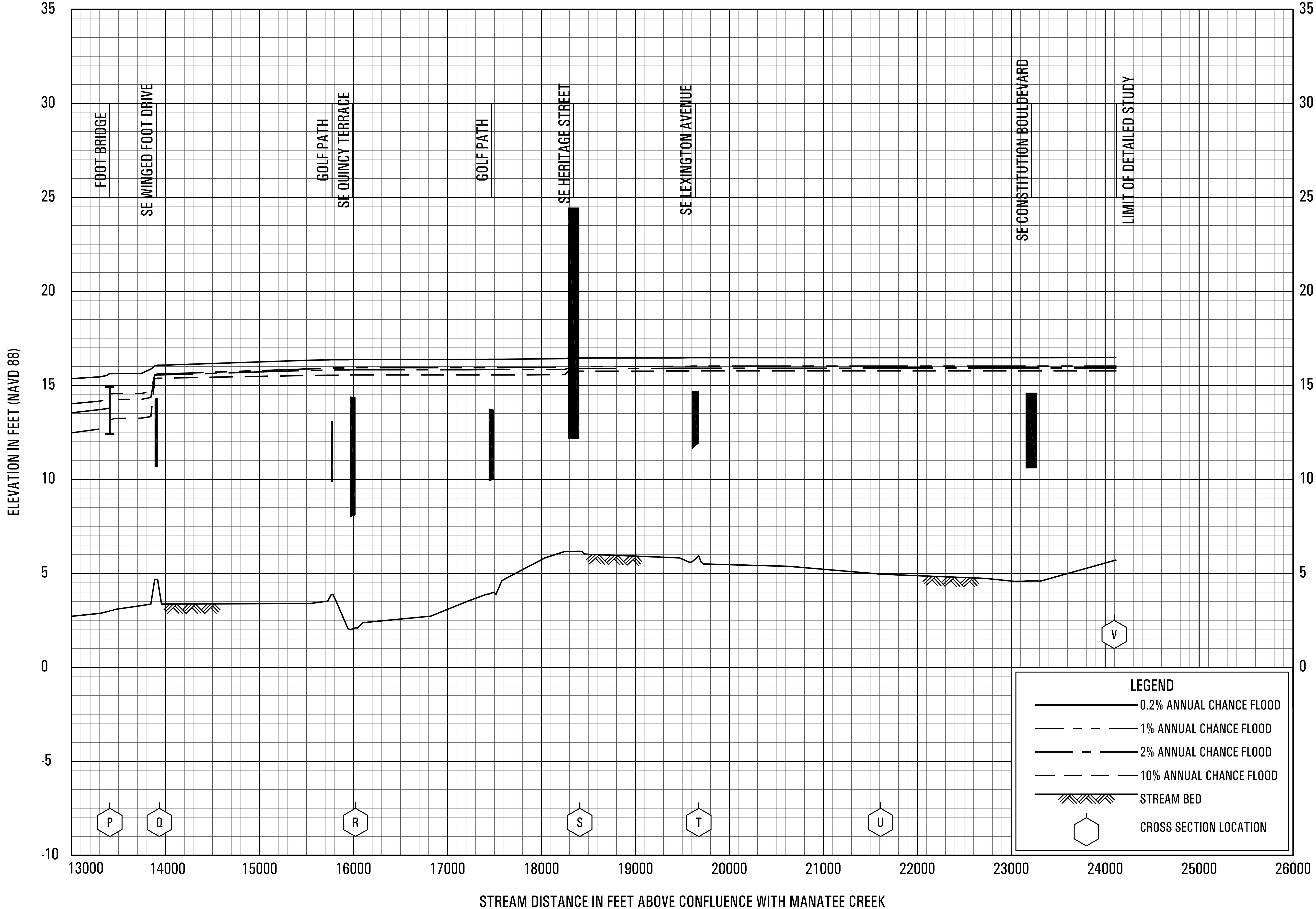
FLOOD PROFILES

EAST FORK CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARTIN COUNTY, FL

AND INCORPORATED AREAS



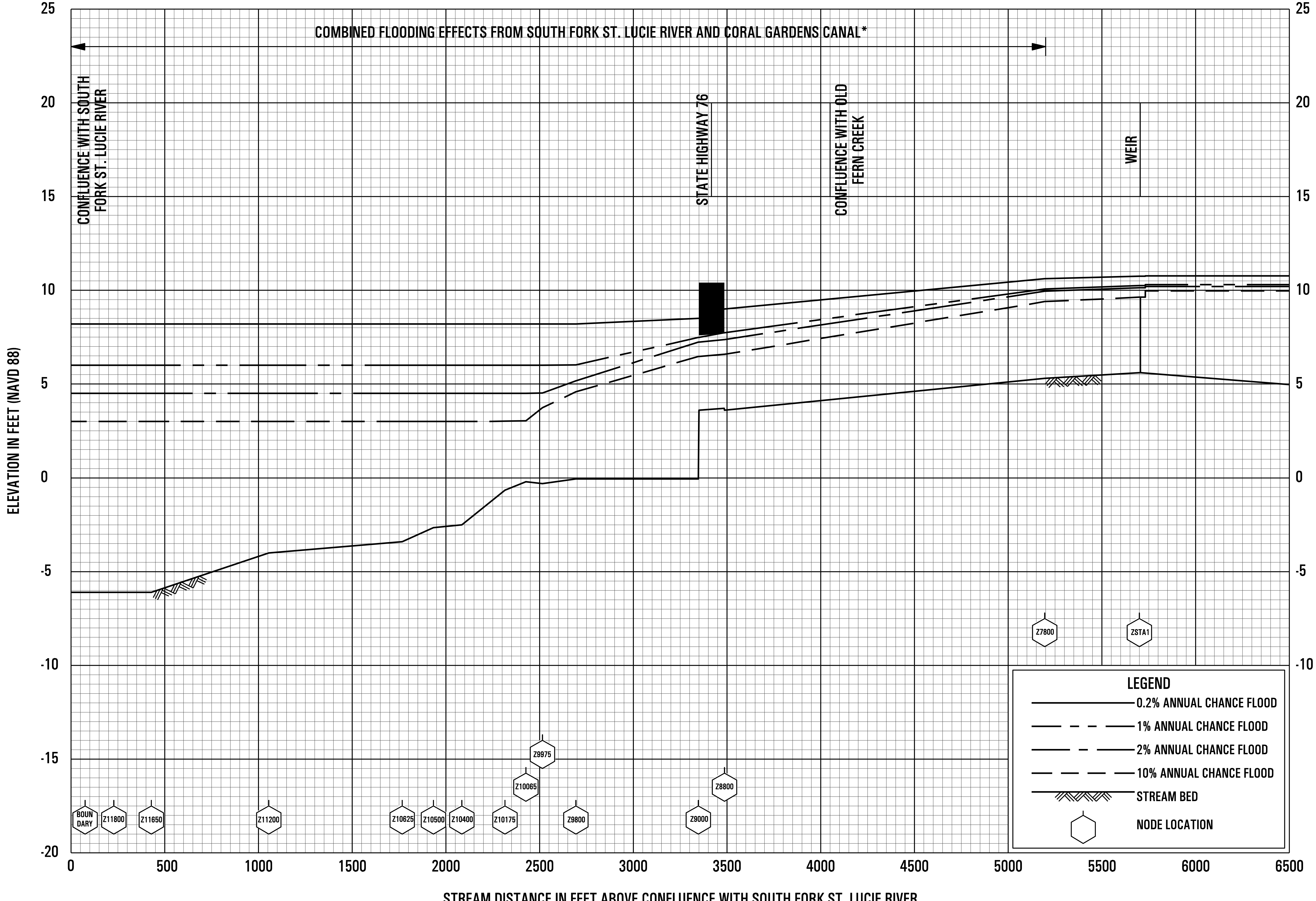
FLOOD PROFILES

EAST FORK CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARTIN COUNTY, FL

AND INCORPORATED AREAS



*INCLUDES COASTAL COMBINED PROBABILITY

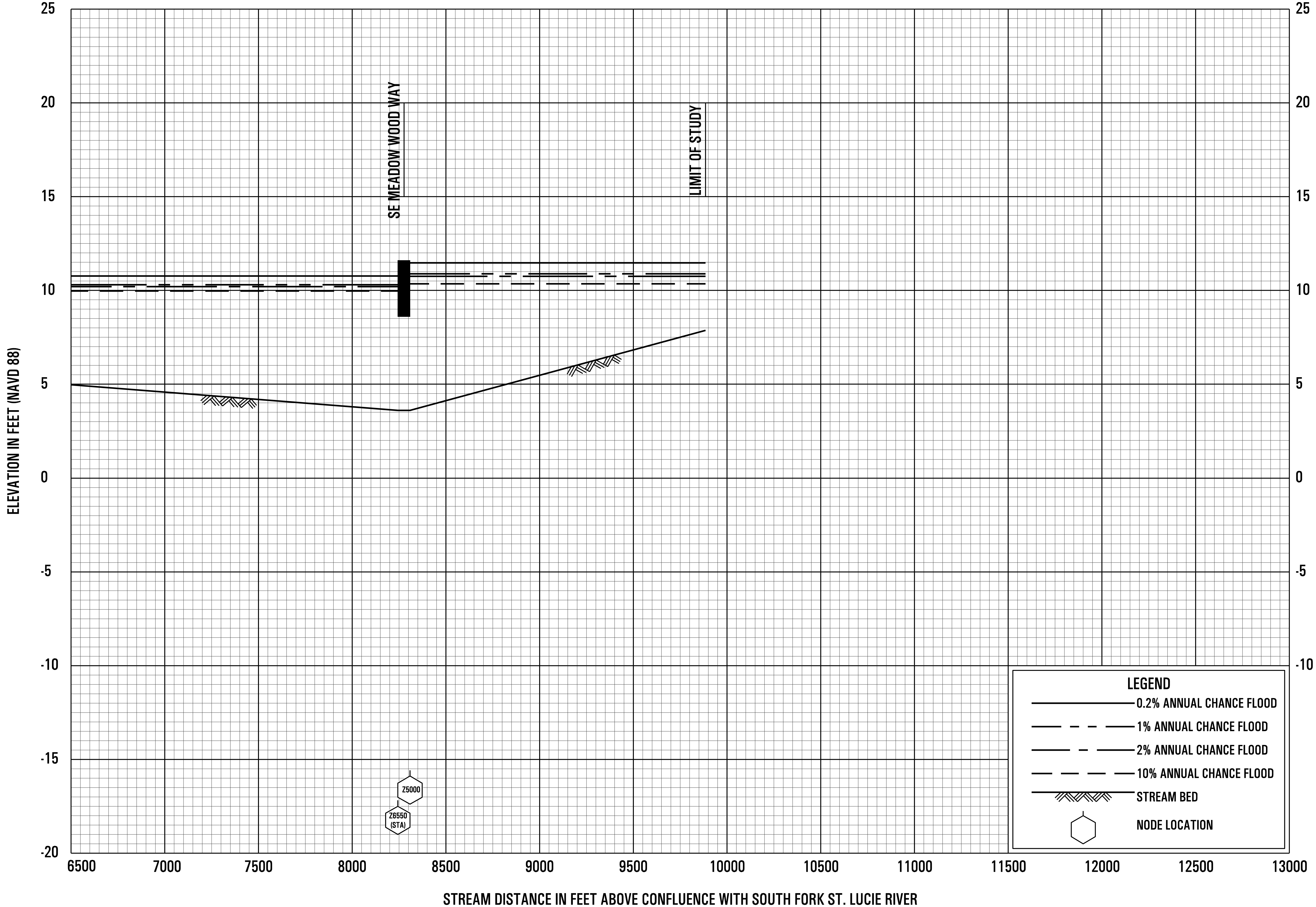
FLOOD PROFILES

FERN CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARTIN COUNTY, FL

AND INCORPORATED AREAS



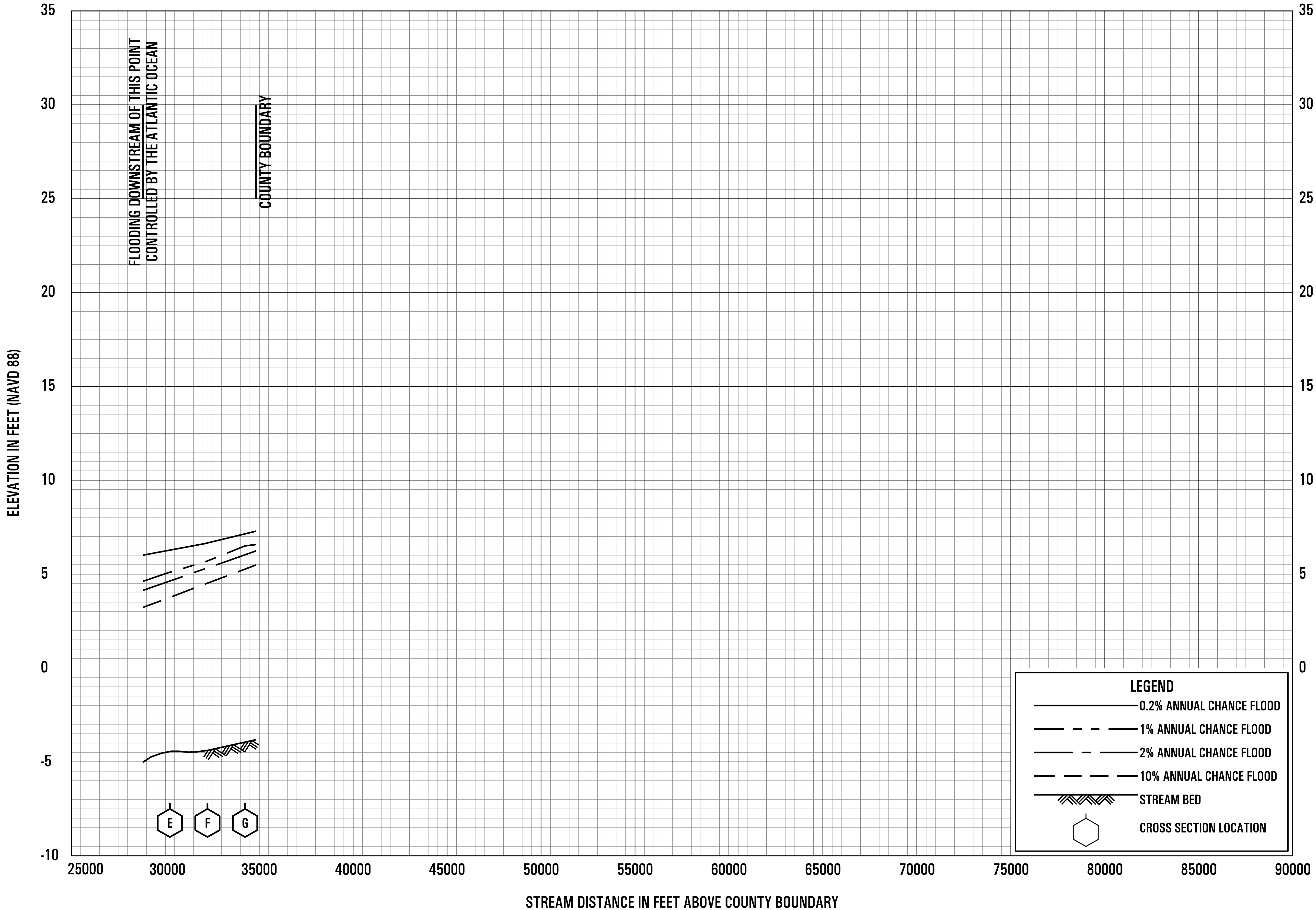
FLOOD PROFILES

FERN CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARTIN COUNTY, FL

AND INCORPORATED AREAS



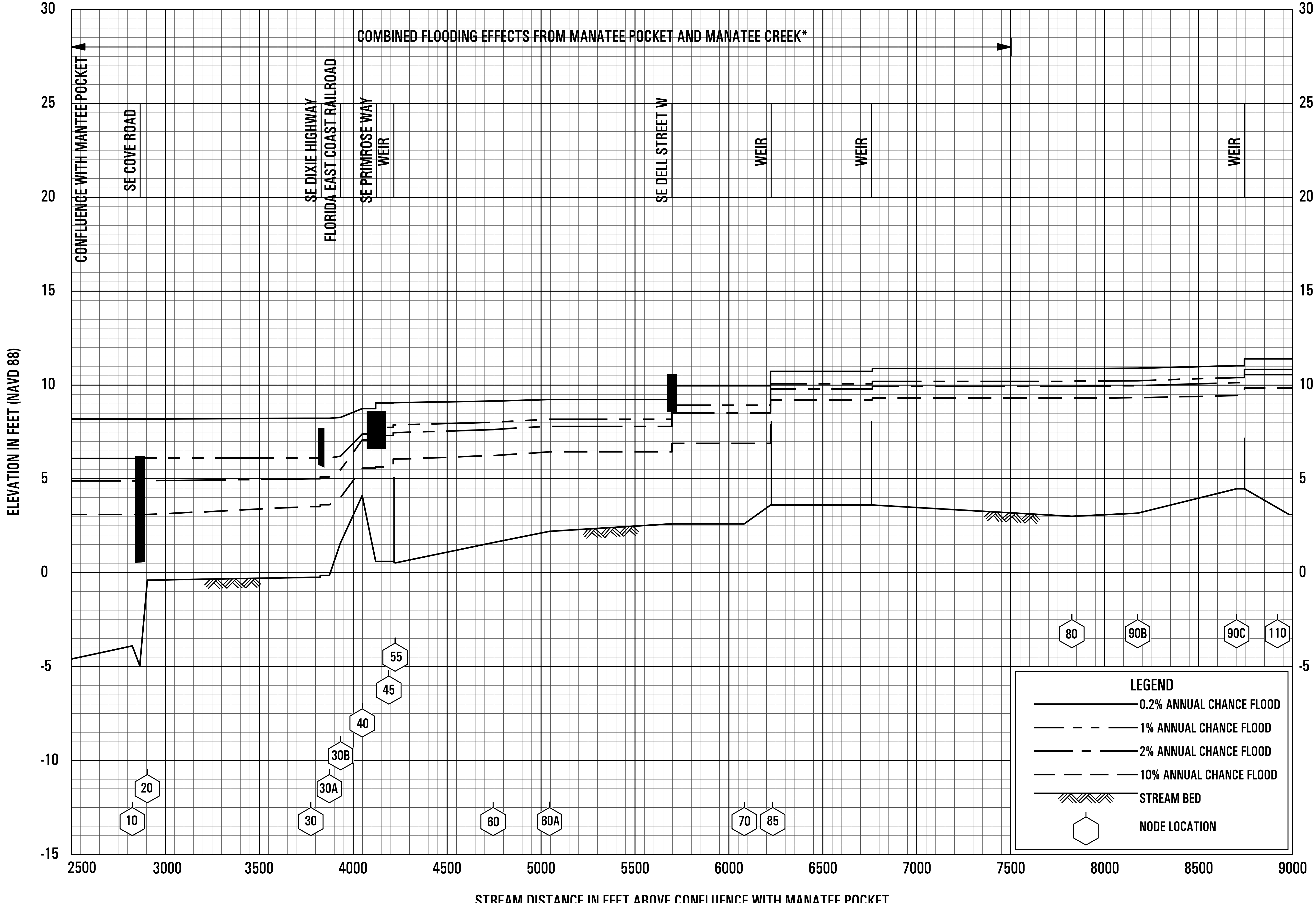
FLOOD PROFILES

LOXAHATCHEE RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARTIN COUNTY, FL

AND INCORPORATED AREAS



*INCLUDES COASTAL COMBINED PROBABILITY

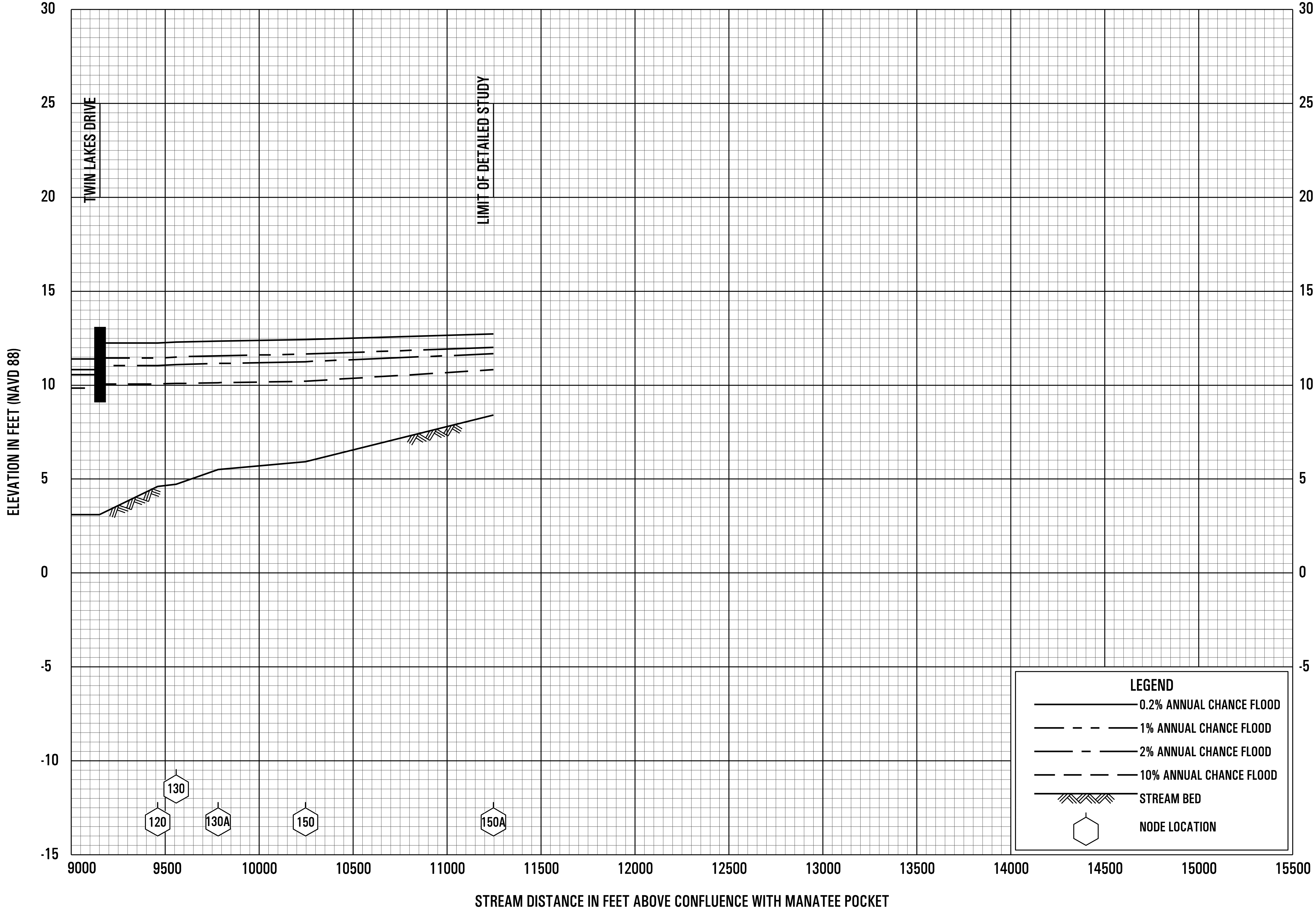
FLOOD PROFILES

MANATEE CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARTIN COUNTY, FL

AND INCORPORATED AREAS



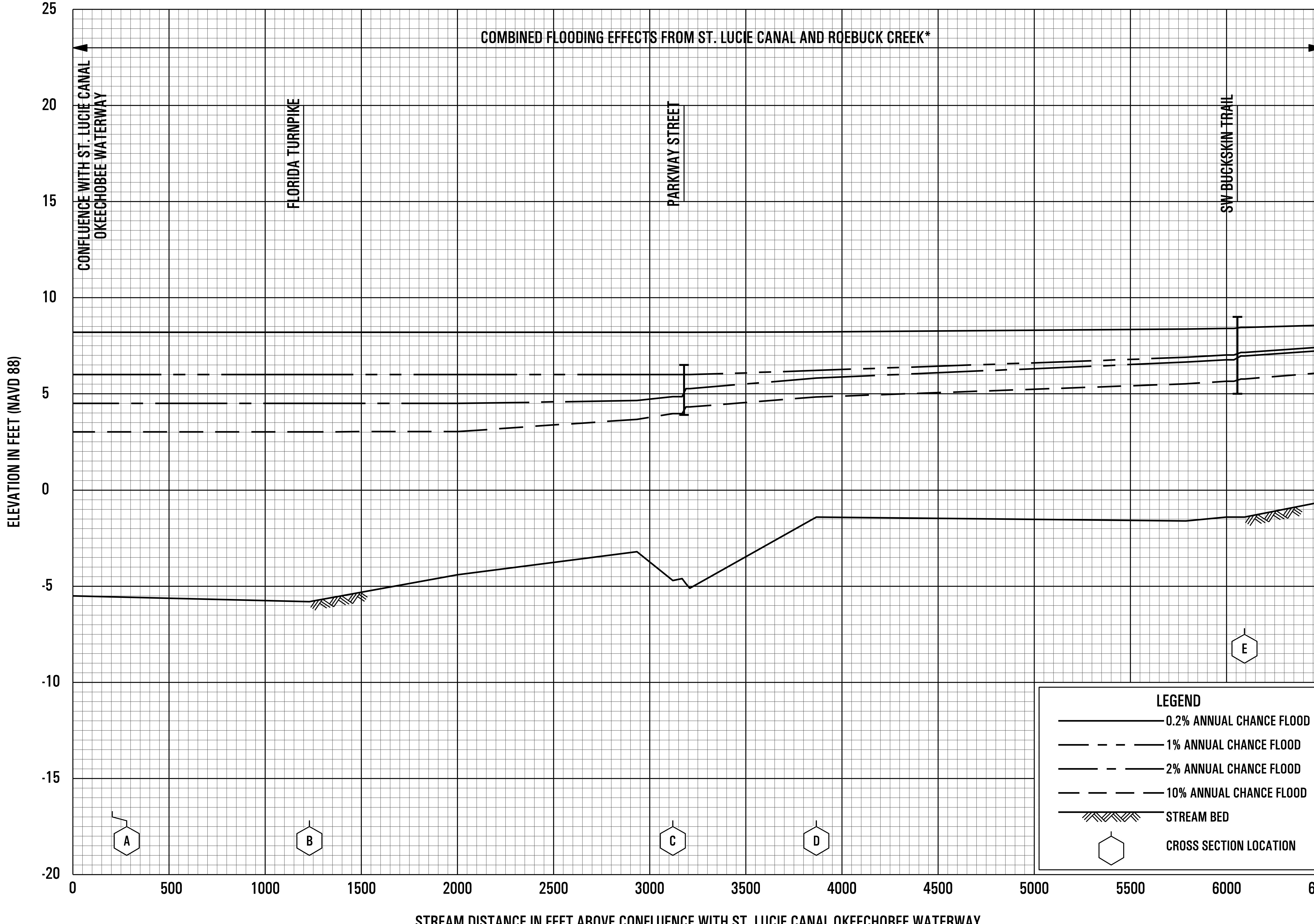
FLOOD PROFILES

MANATEE CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARTIN COUNTY, FL

AND INCORPORATED AREAS



*INCLUDES COASTAL COMBINED PROBABILITY

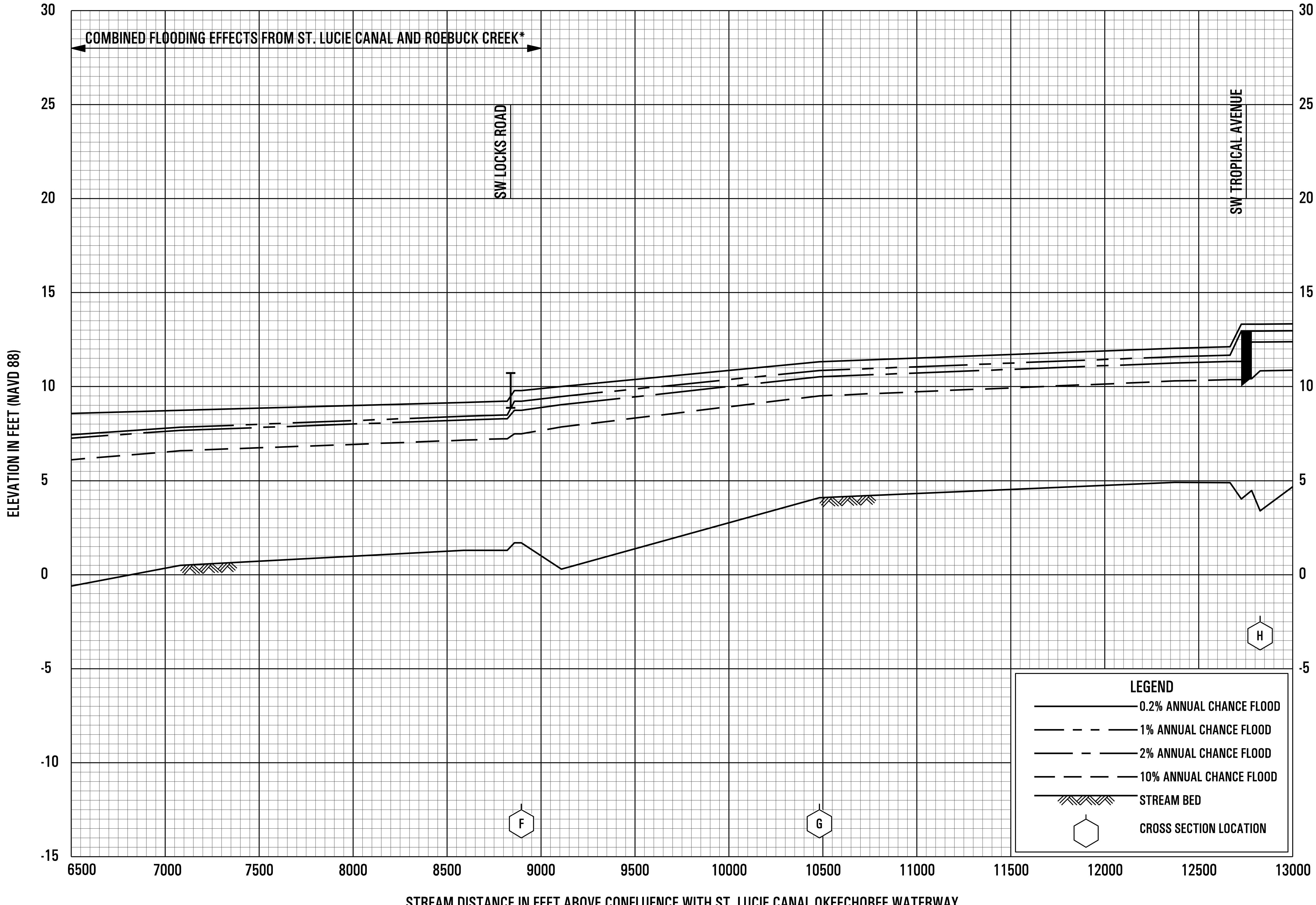
FLOOD PROFILES

ROEBUCK CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARTIN COUNTY, FL

AND INCORPORATED AREAS



*INCLUDES COASTAL COMBINED PROBABILITY

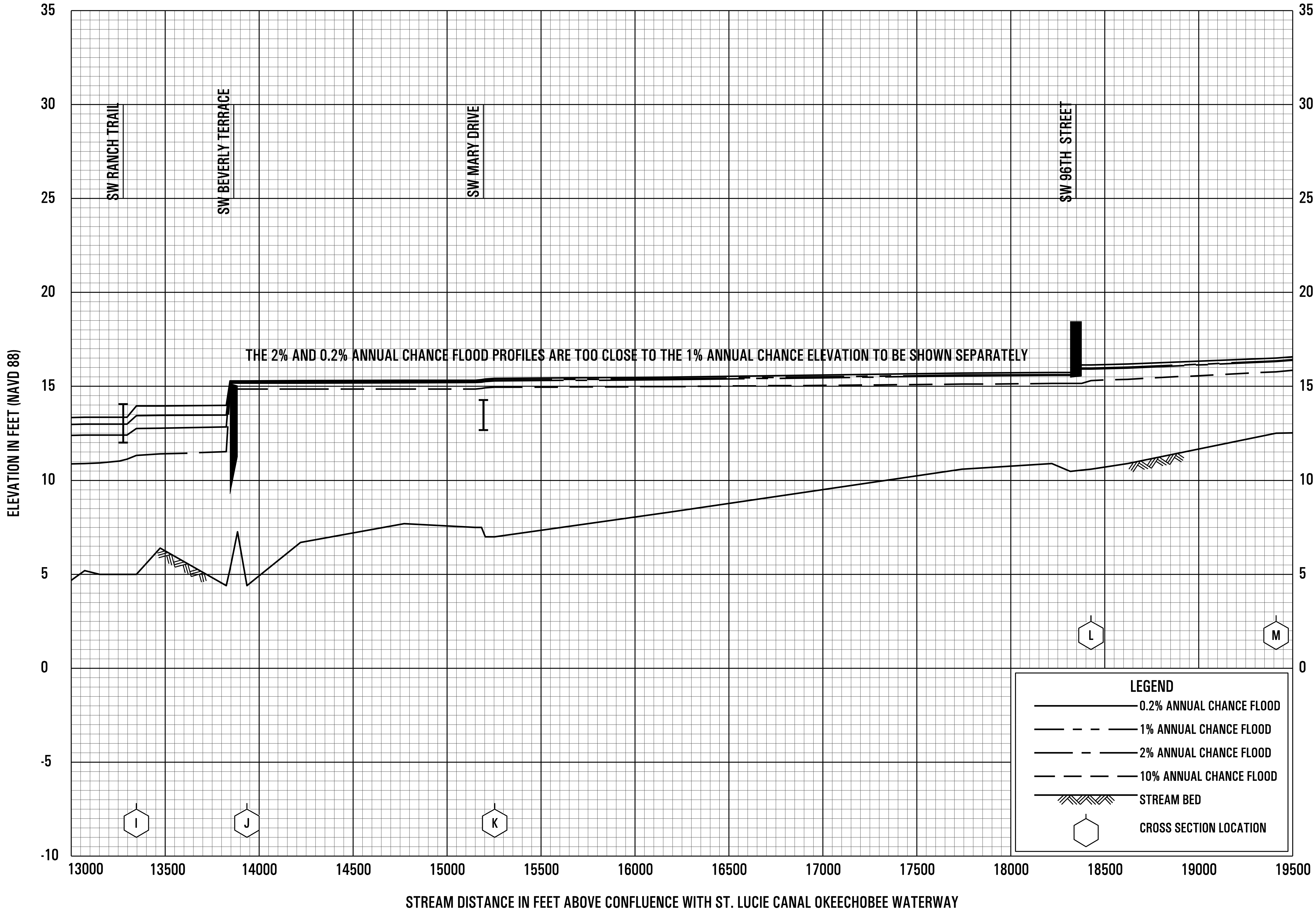
FLOOD PROFILES

ROEBUCK CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARTIN COUNTY, FL

AND INCORPORATED AREAS



FLOOD PROFILES

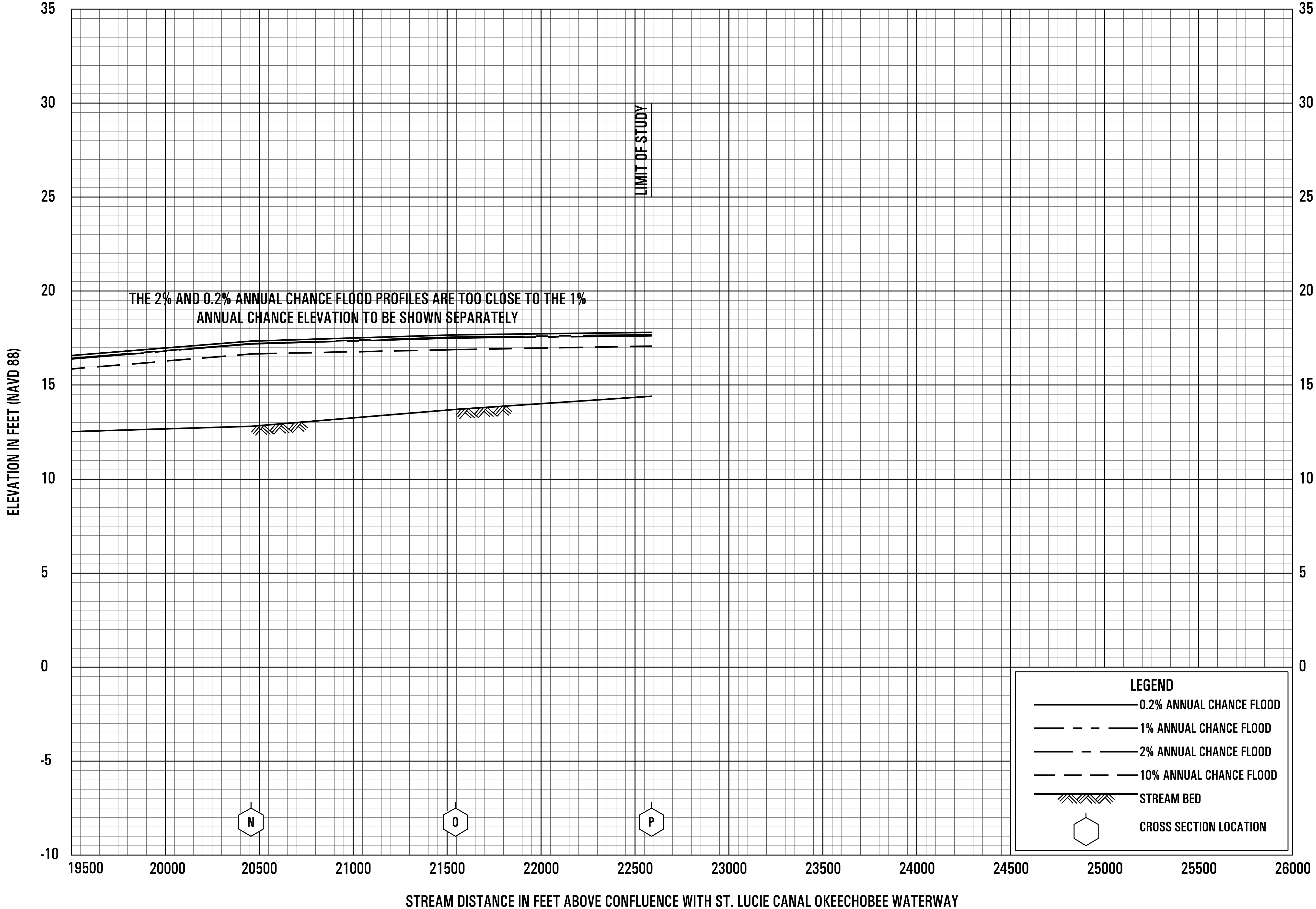
ROEBUCK CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARTIN COUNTY, FL

AND INCORPORATED AREAS

19P



FLOOD PROFILES

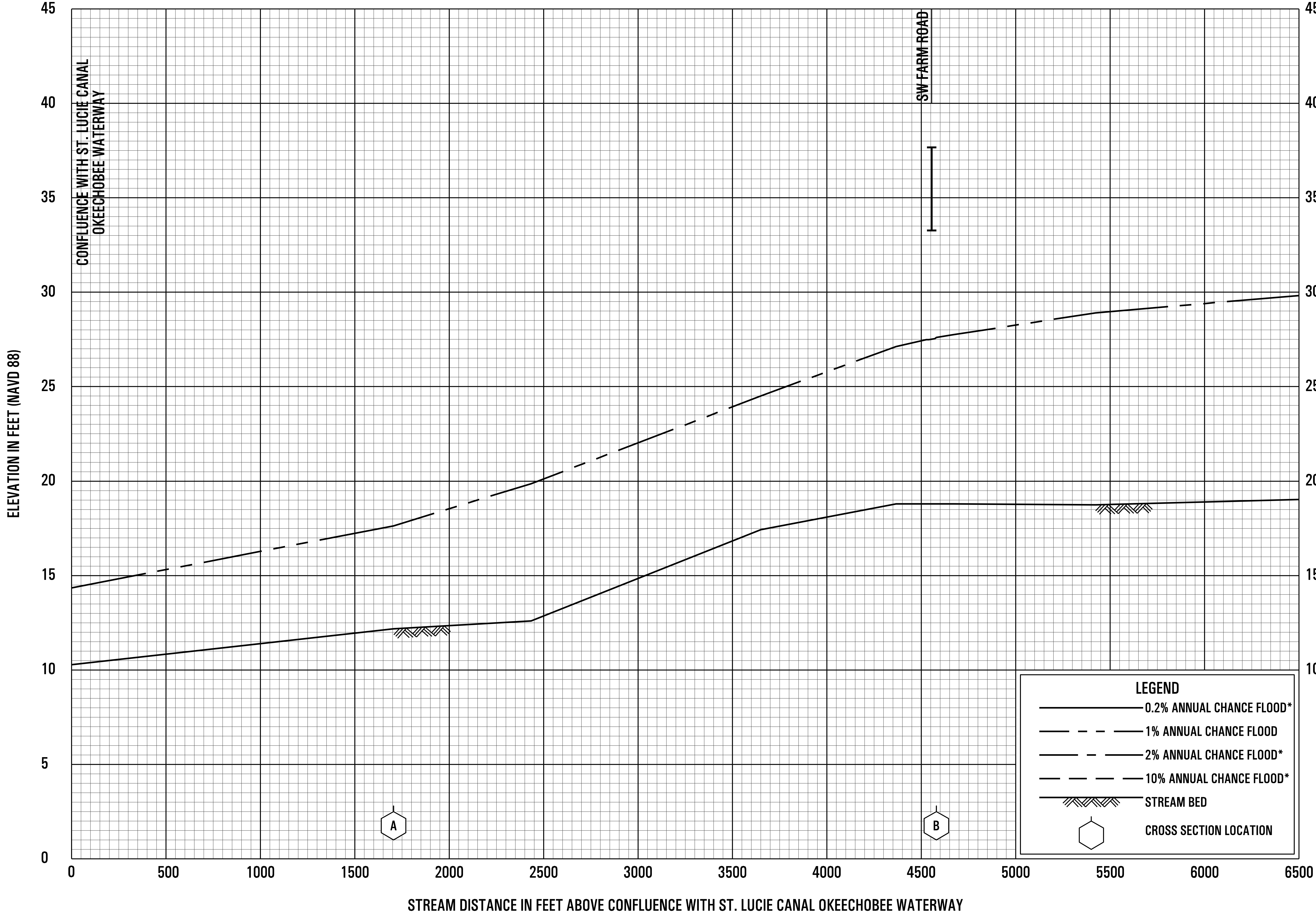
ROEBUCK CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARTIN COUNTY, FL

AND INCORPORATED AREAS

20P



*DATA NOT AVAILABLE

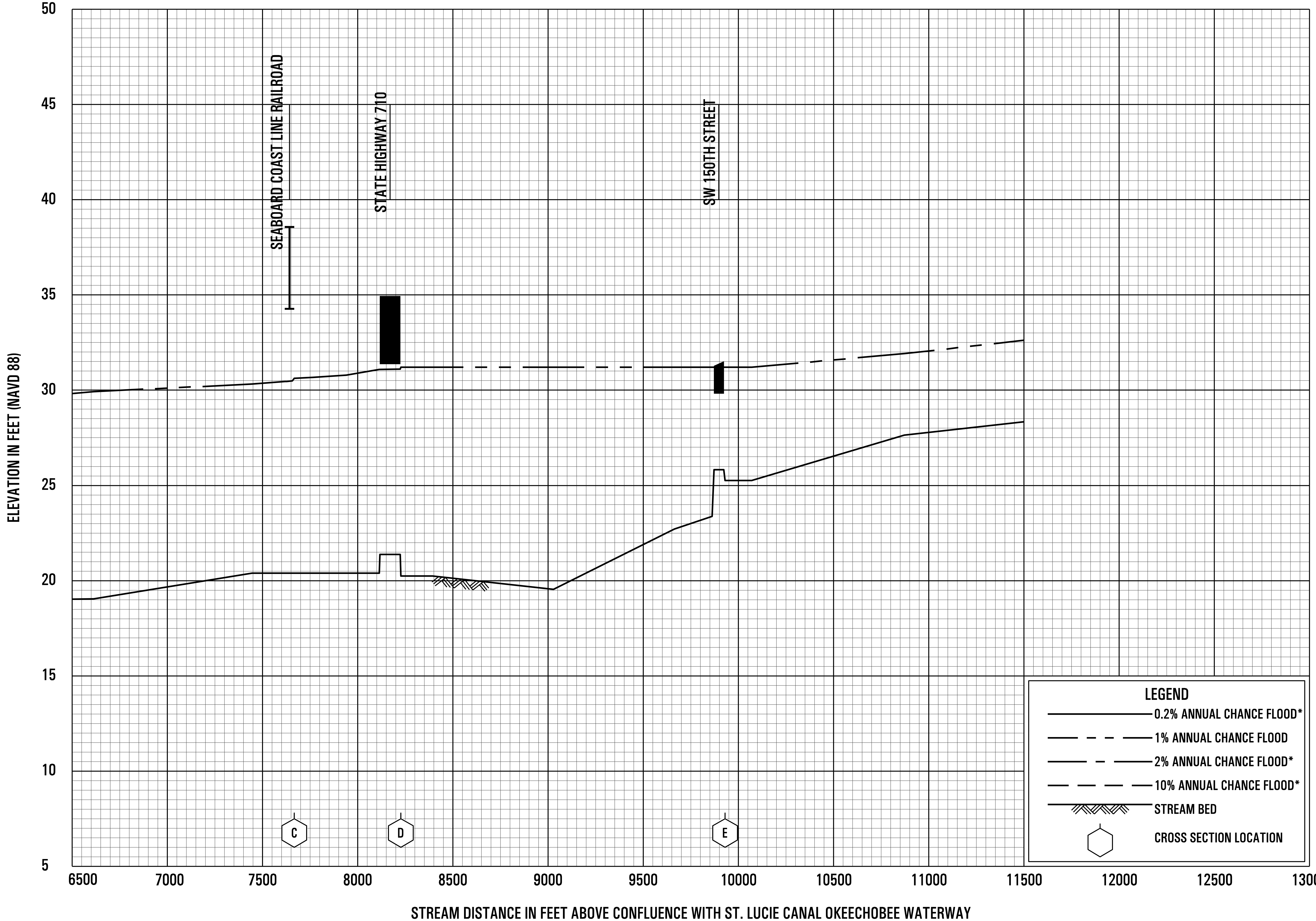
FLOOD PROFILES

ROWLAND CANAL

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARTIN COUNTY, FL

AND INCORPORATED AREAS



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FLOOD PROFILES

ROWLAND CANAL

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MARTIN COUNTY, FL

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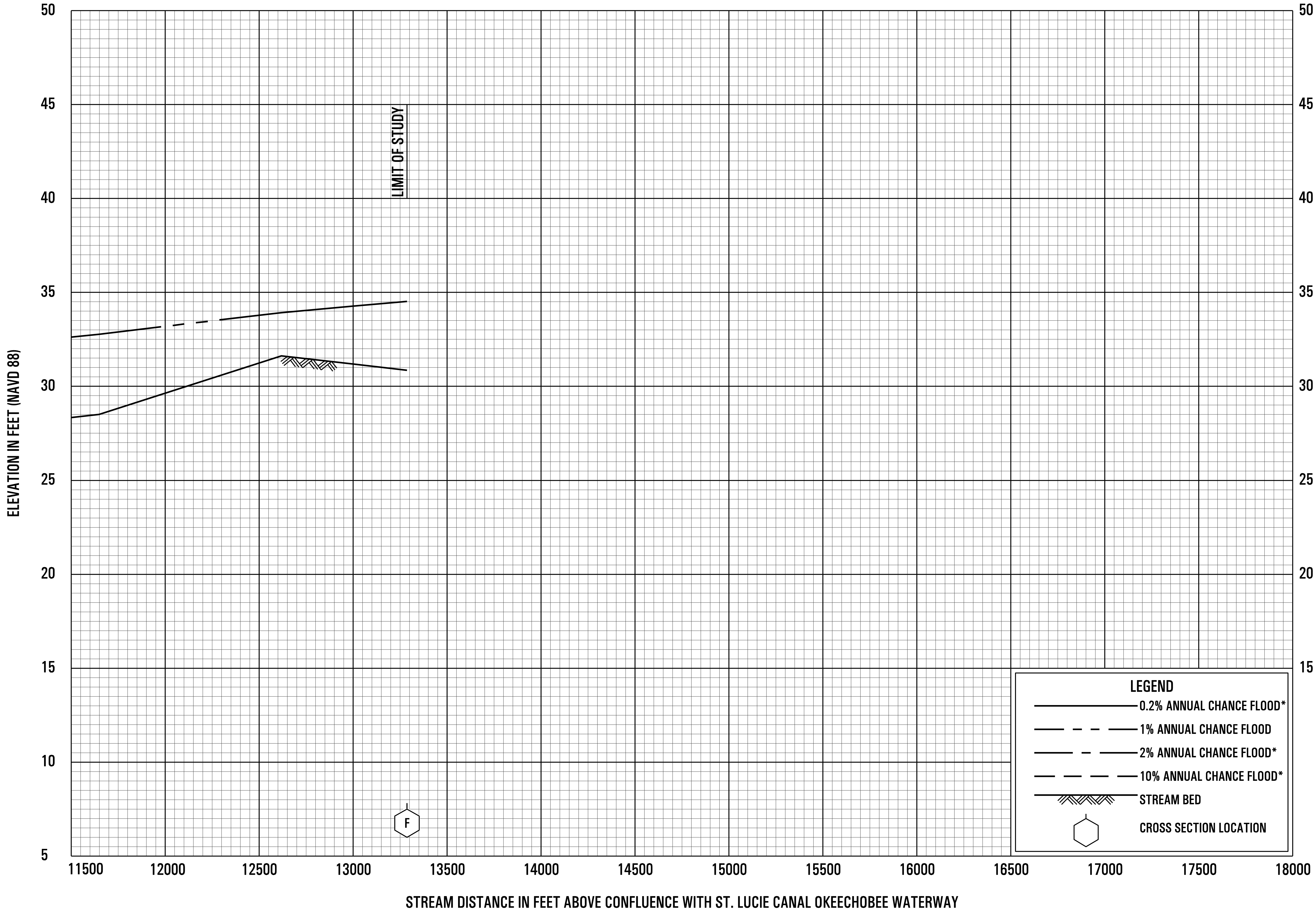

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FLOOD PROFILES

ROWLAND CANAL

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARTIN COUNTY, FL

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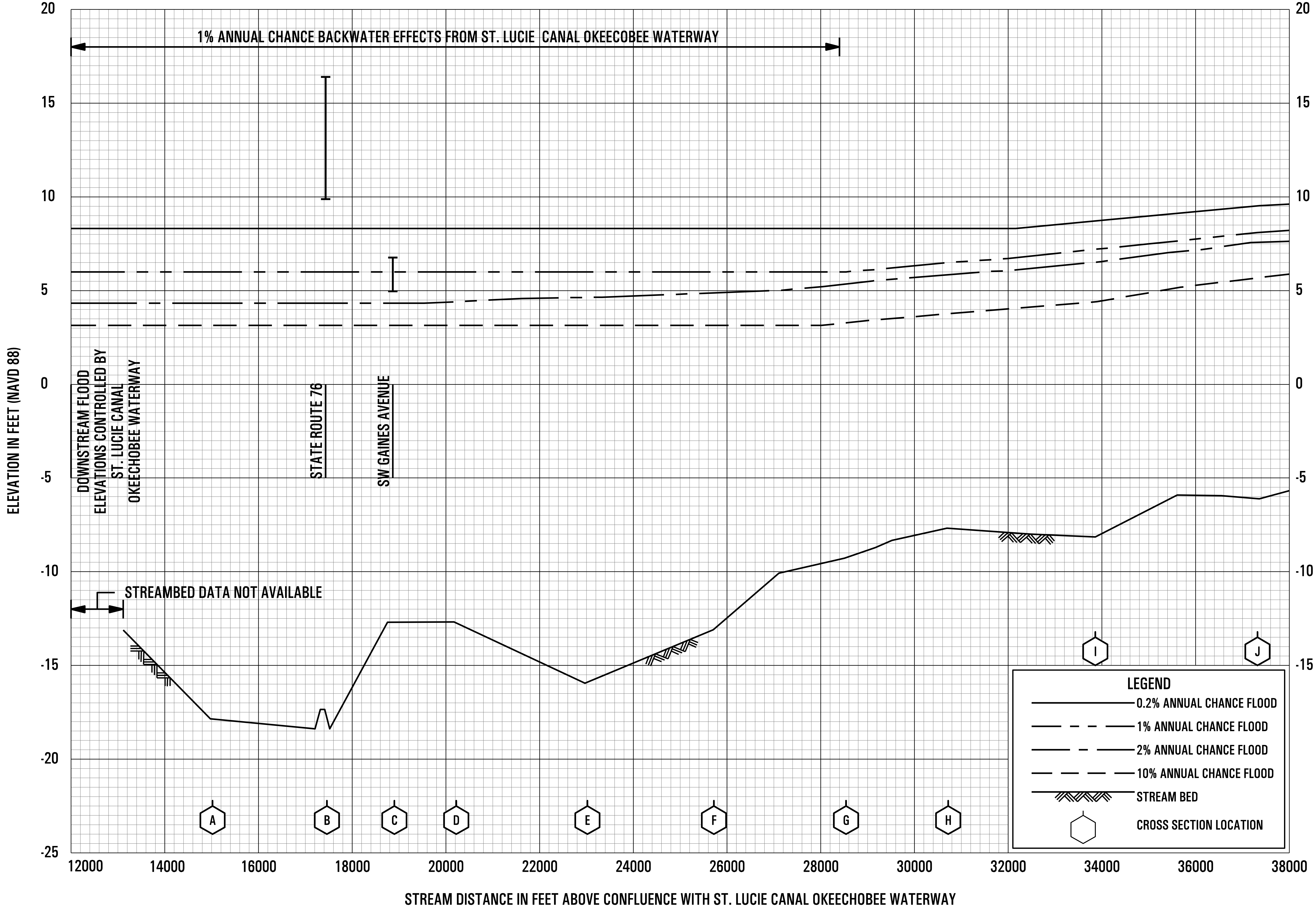


FLOOD PROFILES

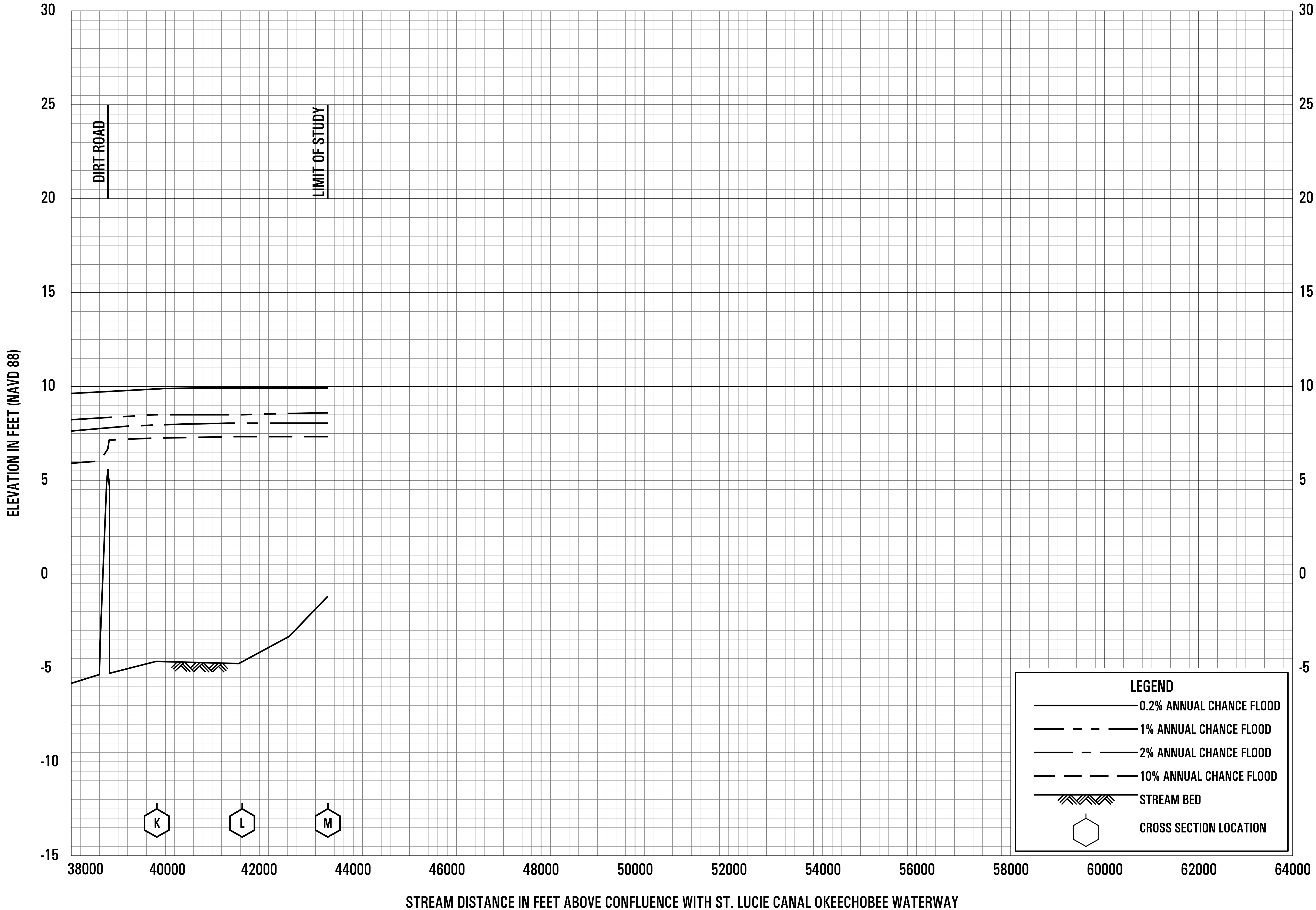
SOUTH FORK ST. LUCIE RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARTIN COUNTY, FL

AND INCORPORATED AREAS

24P



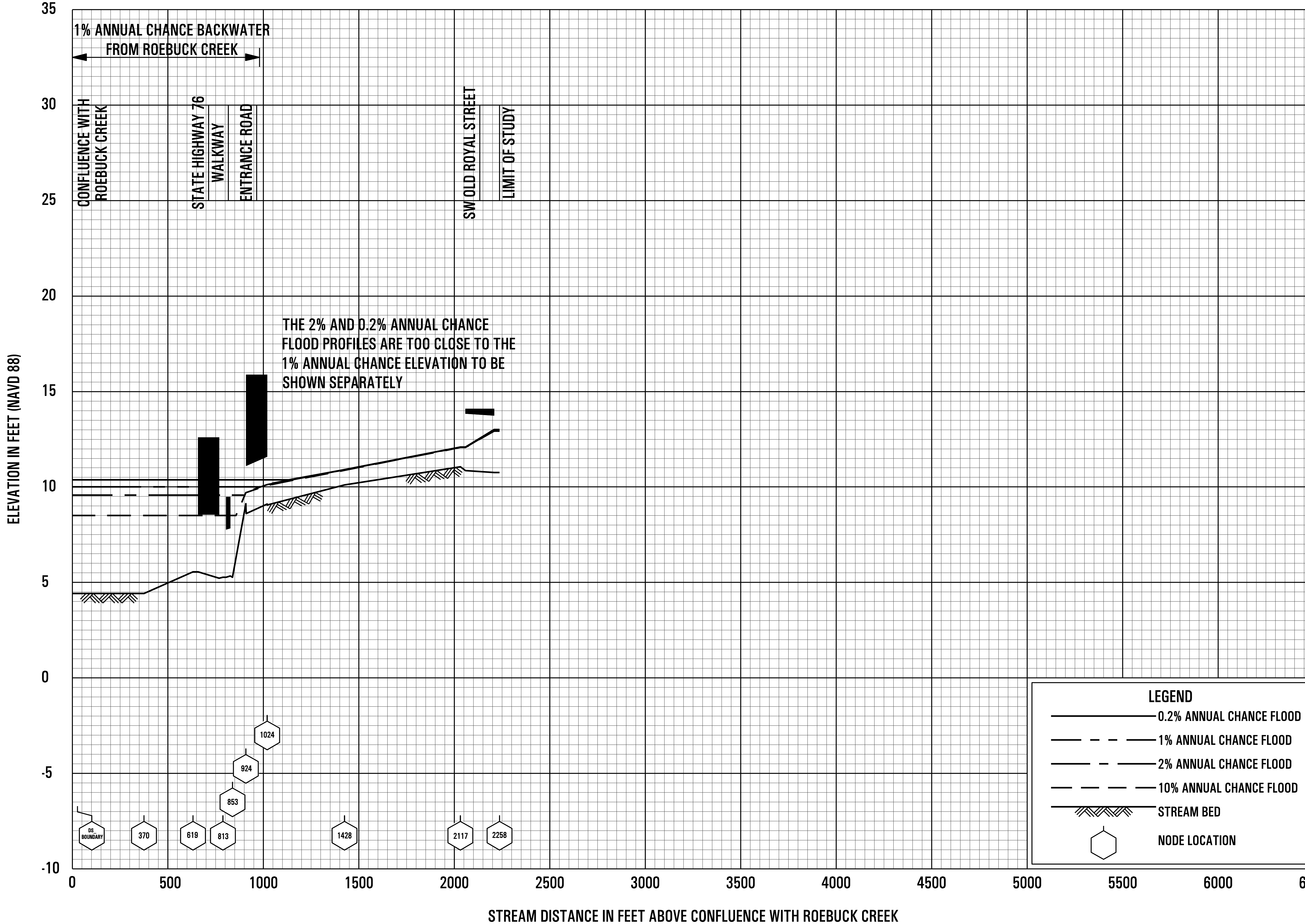
FLOOD PROFILES

SOUTH FORK ST. LUCIE RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARTIN COUNTY, FL

AND INCORPORATED AREAS



FLOOD PROFILES

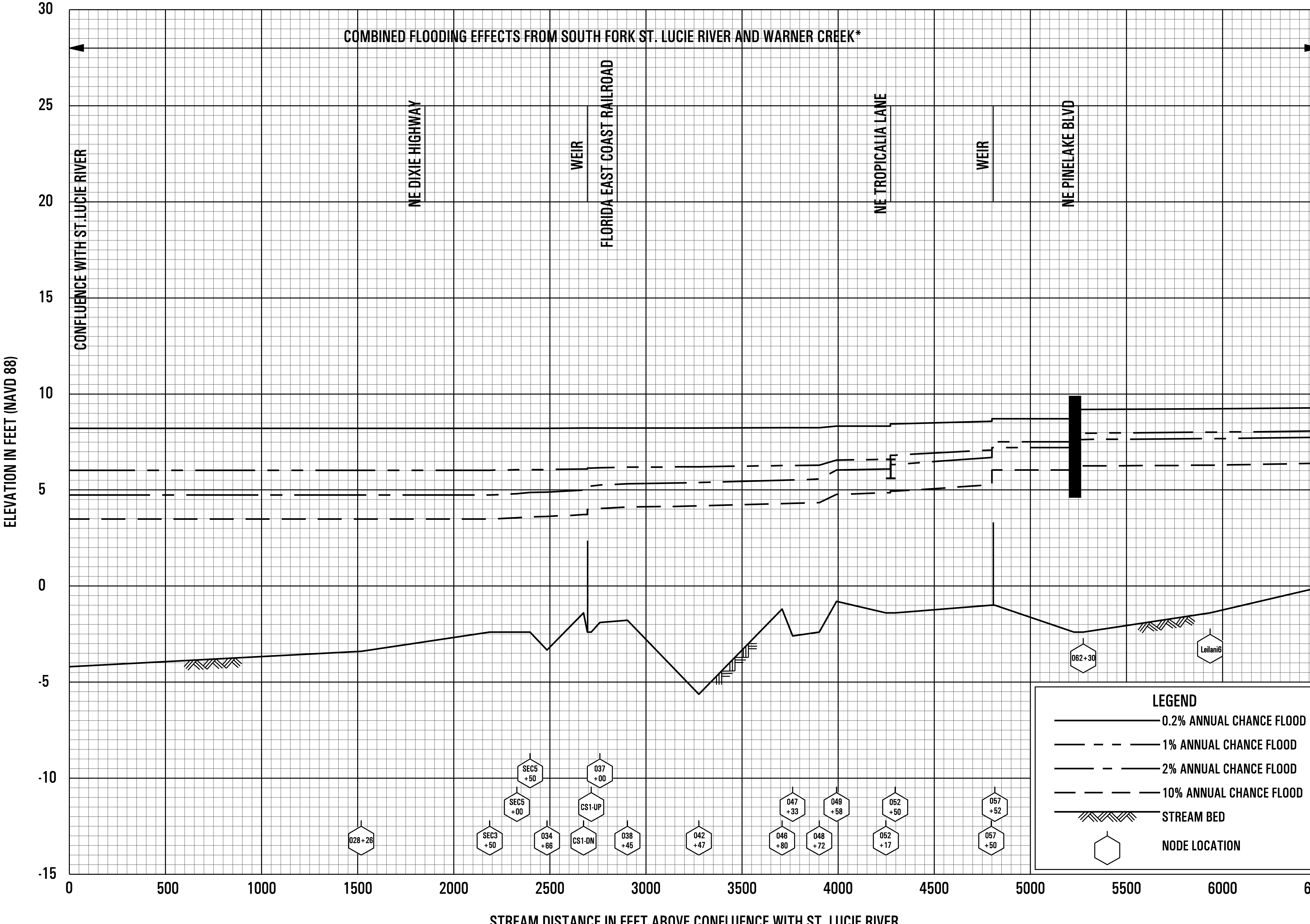
UNNAMED TRIBUTARY 1 TO ROEBUCK CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARTIN COUNTY, FL

AND INCORPORATED AREAS

26P



*INCLUDES COASTAL COMBINED PROBABILITY

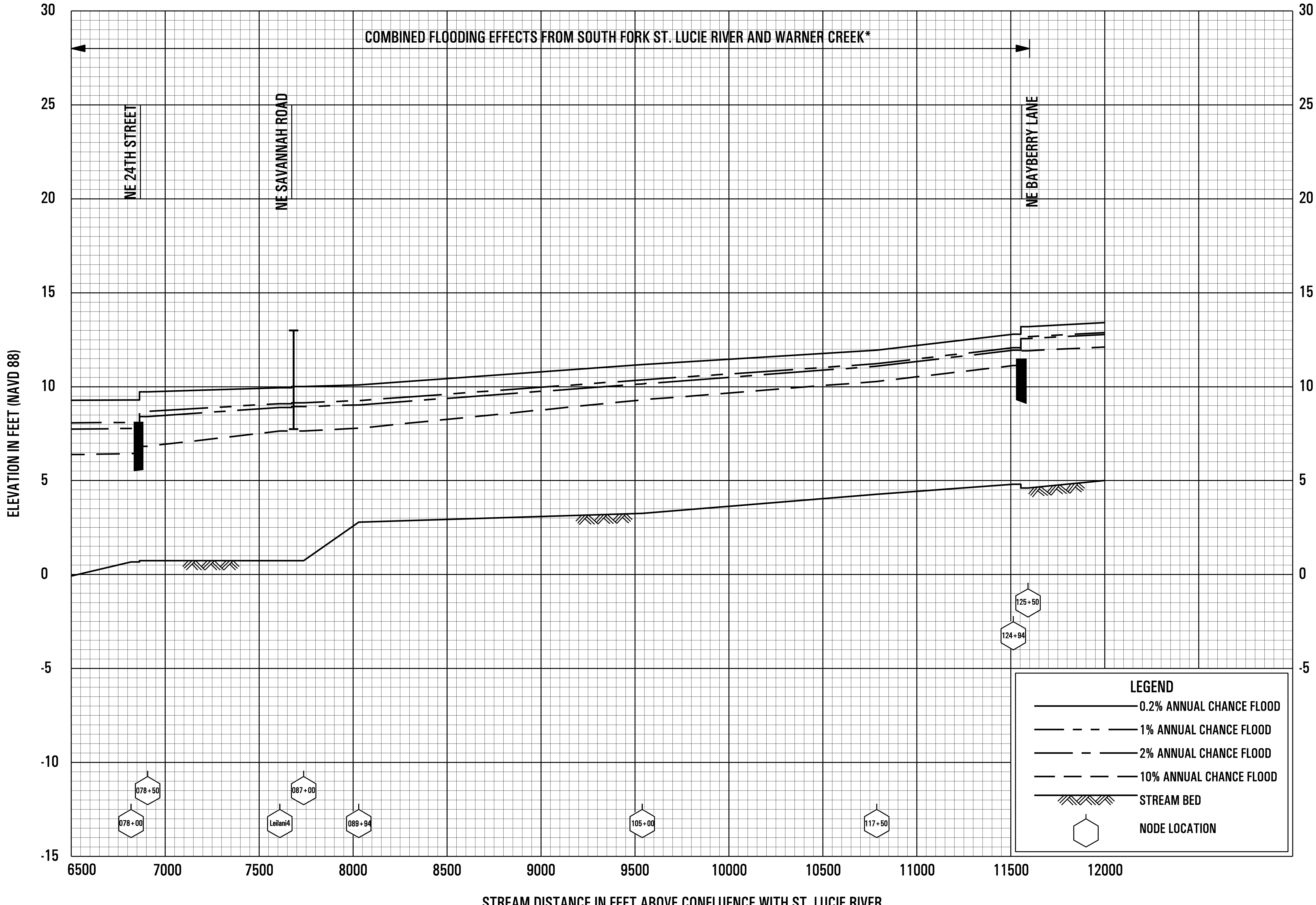
FLOOD PROFILES

WARNER CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARTIN COUNTY, FL

AND INCORPORATED AREAS



*INCLUDES COASTAL COMBINED PROBABILITY

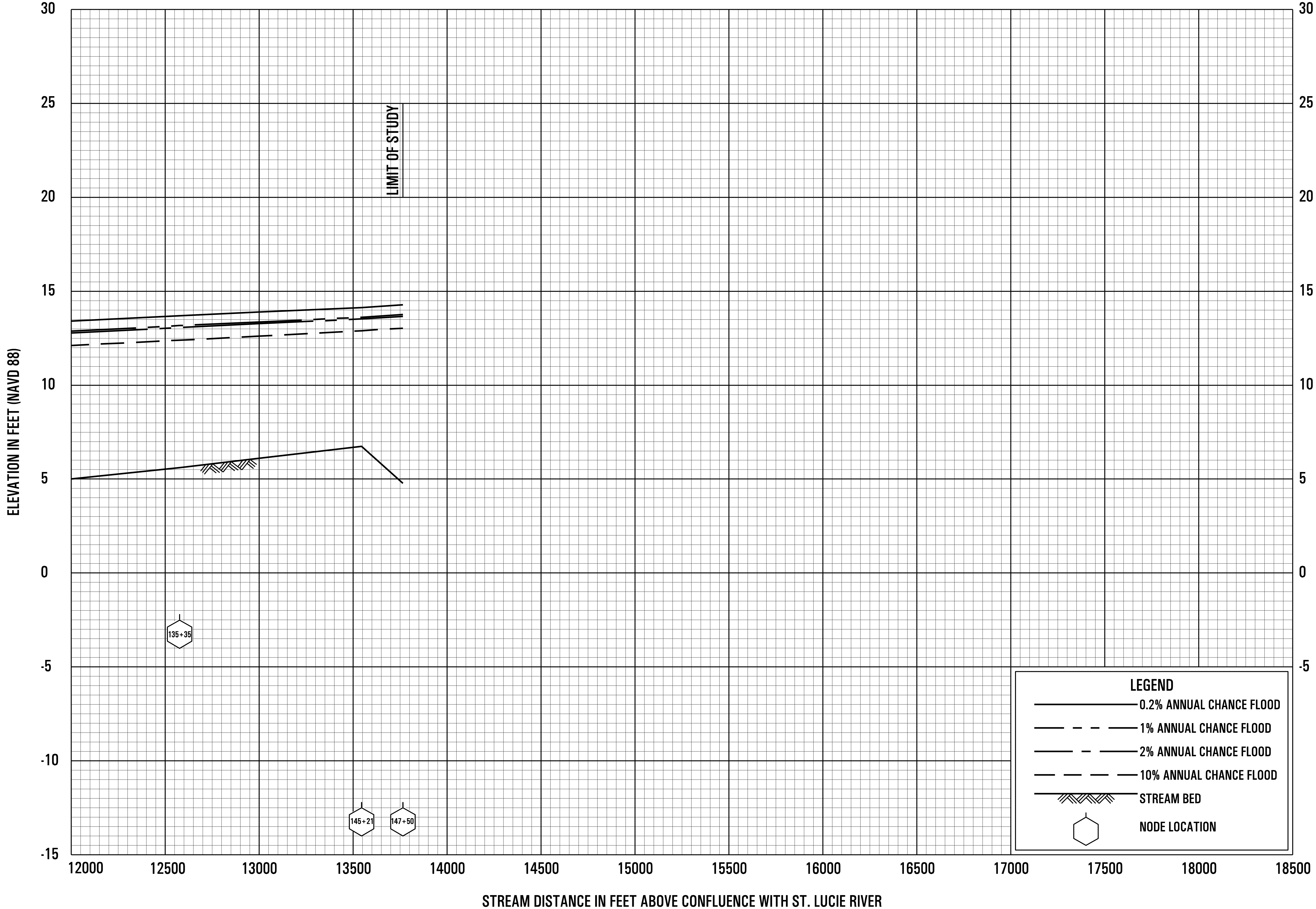
FLOOD PROFILES

WARNER CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARTIN COUNTY, FL

AND INCORPORATED AREAS



FLOOD PROFILES

WARNER CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

MARTIN COUNTY, FL

AND INCORPORATED AREAS